THE
POPULAR SCIENCE
MONTHLY.

OCTOBER, 1912

THE GUAYULE—A DESERT RUBBER PLANT[1]

By Professor F. E. LLOYD
MCGILL UNIVERSITY

PERHAPS no statement in regard to the source of our commercial rubbers is more surprising to one unacquainted with this particular field than that over 200 species of plants contribute to the sum total of the crude material which comes to the market. Indeed, that "rubber plant," which is frequently used as a household decoration is usually thought to be chiefly responsible, but this is far from the truth. This same rubber plant, however, furnishes us with a point of departure for the present account in the fact, well known to every one who has but slight acquaintance with it, that when injured, a milky fluid (latex) escapes, which, on drying, becomes translucent, and displays in some degree the familiar properties of india-rubber, or caoutchouc.

Diverse as are the plants which furnish caoutchouc, until a few years ago practically all of it was obtained by "tapping." This consists in cutting into the bark of the plant, and collecting either the milk (latex), to be coagulated immediately or later by various methods, or the strings and masses of coagulated latex adhering to the wound or elsewhere. Among the latex plants the only exception worthy of mention is the so-called grass or root rubber of the Congo. The rhizomes of the various species, which, because of their position, can not be tapped, are collected and dried, whereby the rubber is coagulated in the latex-tubes. It is subsequently extracted mechanically by heating, under such conditions as to separate the rubber from the fiber. It will appear evident that whenever the rubber exists as such within the plant, either as the result of coagulation or for any other reason, other methods than that of tapping must be resorted to for its extraction. The practise in the case of the root-rubbers suggest comminution of the

[1] For a full account see F. E. Lloyd, "Guayule, a Rubber Plant of the Chihuahuan Desert," Carnegie Institution of Washington, Publication 139.

tissues, accompanied by the agglomeration of the contained rubber. The methods of the chemist have suggested extraction by the use of suitable solvents, the rubber being recovered by differential solution and distillation of the solvents. Both these methods have been adapted to the extraction of rubber from the plant which shall claim brief attention in what follows.

I refer to the *guayule,* a low, gray or greenish-gray shrub (Figs. 1 and 2).

FIG. 1. A LARGE AND UNUSUALLY SYMMETRICAL GUAYULE PLANT.

of limited distribution within the Chihuahuan desert, having the center of its geographical area very near to the northern boundary of the state of Zacatecas, Mexico. The southern extension of this area lies somewhat below San Luis Potosi; to the north it is found in the Big Bend country of Texas; here are rather small amounts, and of low stature as compared with the conditions farther to the south. The plant scarcely invades the state of Sonora, and is found only in the western part of Nuevo Leon.

The chief interest attaching to its occurrence in Texas is the fact that it was here first discovered by Dr. J. M. Bigelow "near Escondido (Hidden) Creek." The party of the Mexican Boundary Survey, of which Bigelow was a member, in all probability rested at the large spring which forms the source of this creek, a camping-place for uncounted generations of Indians before the days of the white man. Here, on the McKenzie ranch, east of Fort Stockton, the writer also

camped, finding traces of earlier travelers in arrow-points, beads and old-fashioned army copper cartridge shells. On the surrounding slopes the guayule grows, and probably here Bigelow in 1852 found the specimen on which the description published by Asa Gray in 1859 was based.

For a good many years that specimen (Fig. 3) lay in the Gray Herbarium awaiting its apotheosis. So little was the plant known till recent years that even Bray does not mention it in his description of the vegetation of western Texas, written in 1906.

FIG. 2. A LARGE GUAYULE PLANT, probably 50 years old. The measure is one meter.

FIG. 3. THE SPECIMEN OF THE GUAYULE ON WHICH ASA GRAY BASED HIS ORIGINAL DESCRIPTION. After a photograph.

In fact, it was less than a year and a half previous to this date that, as the result of the efforts of Mr. William A. Lawrence, backed by American capital, it was for the first time demonstrated that it was possible to extract the rubber from the guayule by a mechanical process. On December 25, 1904, 50 pounds of crude guayule rubber were shipped to and sold in New York city. This was the beginning of the immense operations of the Continental-Mexican Rubber Co. at Torreón, Coahuila.

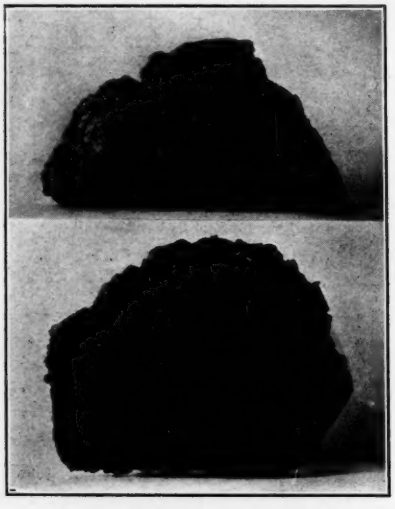


FIG. 4. PREHISTORIC RUBBER FOUND 14 MILES FROM SASCO, ARIZONA.

But the earlier history of the industry in Mexico has a larger romance than can well be related in the short space here allotted. The more salient points only may be mentioned. Just as the Mayas in the south, and in the Amazon region, made playing balls of latex rubber, so, in the north, guayule rubber was known and used by the aborigines. But the task of extraction was for these more indirect, for they chewed the bark of the plant, in order to separate out the fibrous tissue and to agglomerate the rubber. Assiduous mastication on the part of a sufficient number of devotees to pelota turned out in a short time a resilient if crude rubber ball. There is evidence that this plaything found its way by barter to the coast of the Gulf of California and probably the peoples to the north and east also obtained it. It is a matter of unusual interest that the aboriginal Papagos used rubber. Late in 1909 an *olla,* or earthenware jar, was unearthed at some depth on the site of an ancient village near Sasco, Ariz. In it were two round masses of rubber which, aside from a vitreous and fissured external layer, still displayed the texture, resiliency and odor of a dry and almost resin-free product. A generous piece (Fig. 5) of one of the masses was presented to the writer by Professor A. R. H. Forbes, of Tucson, Ariz., for study, but the microscopic evidence does not support the most natural supposition that it is guayule rubber, but more probably that it is a latex rubber which found its way northward from the more remote parts of Mexico. It is fairly certain, therefore, that rubber was an article of barter over a rather wide stretch of country.

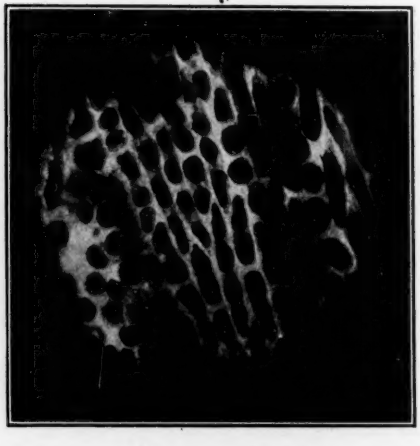


FIG. 5. MICROSCOPIC APPEARANCE OF GUAYULE RUBBER IN THE CELLS OF THE RUBBER-BEARING TISSUE.

At the present time not only guayule, but two at least of its congeners, "*mariola*" (*Parthe-*

nium incanum) and "*tatanini*" (*Parthenium lyratum*) afford material to the hand of the ball enthusiast of northern Mexico. These two plants, however, contain rubber in very meager quantity as compared with guayule.

This method of extracting the rubber, *viz.*, by mastication, very naturally suggested the course of manufacture. As early as 1888 it was

FIG. 6. FLOWERS OF GUAYULE.

proposed to extract the rubber "by a process of grinding and washing." A test carried out in New York by the interested company showed that the "bark" contained at least "18 per cent. rubber comparable to the best grade of centrals." But nothing further was done and samples sent about this time from Mexico to Germany and England, found no favor.

In 1900, however, some Germans established a laboratory at San Luis Potosi, the birthplace of the industry in Mexico. Two years later, as a result of the San Luis investigations, a factory was started at Jimulco, in which a method of extraction by solvents was used. It was at this time that the experimental operations carried on by Mr. Lawrence and leading to the practical solution of the mechanical method, culminated in the first commercial shipment of crude guayule rubber, extracted by mechanical means. This was the American and, indeed, most important contribution to the solution of the problem, and led, as above stated, to the establishment of the works of the Continental-Mexican Rubber Company.

That the rationale of the mechanical operations involved may be appreciated, we may now consider in some detail the structure of the plant.

FIG. 7. PROBABLY THE BEST STAND OF GUAYULE IN MEXICO, SIERRA GOJADA, DGO.

The guayule shrub, having the low, tree-like habit of many desert perennials, belongs to the family Compositæ of which our daisies and dandelions are familiar examples. The most obvious proof of this relationship is seen at once in the flowers, which, while not very daisy-like at first glance, are seen in somewhat closer examination to follow the same pattern. Instead, however, of the rather numerous white rays surrounding the yellow center of the well-known daisy, in the guayule the short rays are but five in number, and these, as well as the relatively large disc, are of a uniform pale, dullish yellow. The flowers, unusually for the Compositæ, have a distinct and very pleasing fragrance, and are visited, and incidentally pollinated, by various small insects, even mosquitoes. The leaves, which may or may not be lobed, according to their development, are clothed with a dense, smooth covering of T-shaped hairs, imparting to them the silvery sheen characteristic of the shrub as a whole.

The smaller twigs are similarly clothed, the hairiness giving way at length to a smooth gray bark, which, with advancing age, becomes longitudinally fissured. On the oldest and largest stems, transverse fissuring takes place. On the whole, however, the surfaces of the branches are smooth and gray, contributing to the general neutral aspect of the plant. But most striking of all the characters is the "feel" of the lesser branches when bent, suggesting a weak wooden rod encased in a firm rubber tube. The branches have little strength, the mechanical elements of the wood being relatively few. An examination of a

thin slice taken transversely through a smaller branch will enable us to gain some impression of the structure and especially of the manner of occurrence and distribution of the rubber. A twig about a year old taken at the end of a prolonged drought period will serve our purpose.

Referring to Fig. 9, the reader will note that several concentric zones of tissue appear. The outermost is cork (*ck*), which contains no measurable amount of rubber in small branches. In old thick stems the formation of cork in the deeper layers of the next occurring zone, the cortex (*cr* in the figure), results in the cutting out of rubber-bearing tissue, accompanied by a degeneration of the rubber itself, and its consequent loss. The cortex comes next. It is made up of cells of uniform size and shape, containing chlorophyll, and hence green in color. In each cell appears a large droplet of rubber, occupying nearly the whole of the interior space (Fig. 9). Here and there are oval openings which are sectional views of so many canals (*rc*) which traverse the cortex longitudinally. These contain a pale yellow resin, a commonly occurring material among the Compositæ. Any slight wound of the cortex, however caused, may open one or more of these canals, and the resin may then escape. Hardened, limpid drops of this, either clinging to the branches or fallen on the ground beneath, are always to be seen. The resin appears to be of little economic value, as it is soft. During the mechanical extraction of rubber, it becomes mixed with upwards of 20 per cent. resin.

Inwardly the cortex is broken up by radially placed masses of tissue partly composed of hard "bast" fibers (*bf*, Fig. 9). These correspond to the fibers of the flax in position and origin. Crude guayule rubber

FIG. 8. AN ESPECIALLY FINE STAND OF GUAYULE NEAR LAS CAOPAS, ZACATECAS, MEXICO.

always contains fragments of minute fibers, single or in bundles, and, together with other fragments of cell walls, enable one to determine the origin of the rubber microscopically.

From the inner limit of the cortex, extending toward the center, are radial, wedge-shaped masses of wood (*w*, Fig. 9). This is composed of mechanical tissues with water vessels scattered irregularly throughout it. These may be identified by the width of their lumina. At the inner ends of the wood masses may occur additional bundles of "bast" fibers.

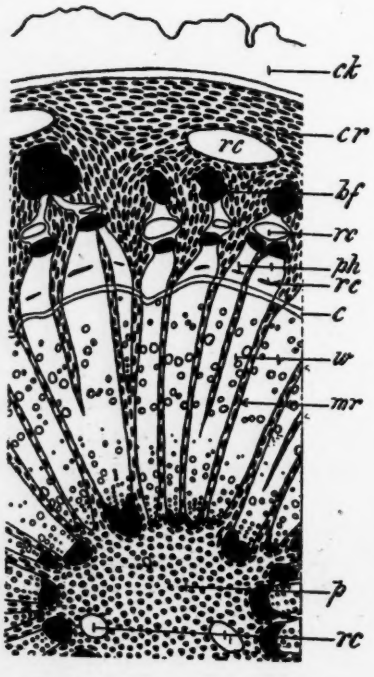


FIG. 9. SEMI-DIAGRAMMATIC SKETCH OF TWO-YEAR-OLD GUAYULE STEM IN TRANSVERSE SECTION.

The central area is occupied by the pith composed (*p* in the figure) of cells identical in every detail except in shape with those of the cortex. The pith cells are nearly circular in outline. They, too, contain rubber. Extending from the pith to the cortex and separating the wood bundles from each other, as also the bast bundles, are the so-called medullary rays (*mr*). Their cells, flattened tangentially, are otherwise quite like those of the cortex and pith, are equally rich in rubber. The pith, again like the cortex, is traversed longitudinally by resin canals. A point of interest here is that the canals with age become plugged by ingrowing masses of tissue, thus in a measure preventing the leakage of resin, especially in the cortex when invaded by cork. In the pith there is an undoubted downward leakage of resin, which, infiltrating into the older wood below, may be detected by chemical analysis. It is thus evident that the resin content of guayule wood is accidental.

By subsequent growth, year by year additional layers of bast and wood are laid down at the inner limit of the cortex, where the cambium, or actively growing tissue, is situated (*c*, Fig. 9). In the bast, and here alone, new resin canals are formed, in radial rows, therefore.

From this very curtailed description, it appears that, in the guayule, the rubber occurs as droplets—really very minute—each enclosed in a sac of albuminous material (protoplasm), this again surrounded by a sac of cellulose (the cell wall). All the cells of the pith, medullary

rays and cortex (and certain others which we need not mention here) contain rubber. There is no rubber in the canals, nor is there any rubber, or rather latex, vessels. It is for this reason that, while it is not possible to extract the rubber by tapping, it is possible, by comminution of tissues, to work together or agglomerate the minute particles of rubber set free by breaking the cells which hold them. It is equally evident that chemical agents may be used for extraction by solution, but this process is of less interest in this connection. We may now pass on to examine the methods of handling the shrub and the process of mechanical extraction.

Collecting the Shrub

The primary problem of collecting the shrub and transporting it to the factory is a difficult one. The shrub, growing wild, being contracted for, the purchaser is free to go and get it. This means that

Fig. 10. Hauling Guayule in Mexico.

peons must be hired to collect the plants in desert places often far removed from water and other supplies. They and their burros find their way into steep and rocky places unapproachable by other means. Having pulled up by the roots a *carga* of shrub, it is loaded on a burro and so off to a central camp, "*campo de guayule,*" placed so as to be approachable by wagon. Here the shrub is baled after the fashion of so much hay. The bales are then hauled to the nearest railway station, sometimes 100 kilometers away, to be shipped to the factory.

Arrived there, the bales are weighed for comparison with the field weight. A certain amount of shrinkage is of course expected, owing to

the drying out of the shrub and breaking off of twigs. Since it was found possible to increase the field weight by methods devious and of little cost, thus selling stones or water at an exceptional price even in a country where that commodity is not cheap, a control by means of tags was devised, enabling a systematic comparison of the field and factory weights of shrub from all areas. The price of water quickly fell.

Manufacture

To keep a large plant running regularly a considerable reserve of shrub must be held. This was formerly stacked in the open, but later, when rapid deterioration was discovered, suitable storage warehouses were provided, thus obviating the deleterious action of the sun. When

Fig. 11. Packing Guayule Rubber at Torréon, Coahuilla.

the shrub is in good condition—that is, sufficiently, but not too dry—the bales are passed out to a washing floor where all dust and soil is removed by a stream of water. The importance of this becomes apparent when it is reflected that the rubber picks up particles of soil and its specific gravity altered, so making the separation of rubber and bagasse more difficult.

The shrub is now run between the steel rolls of a crusher which, running at differential speeds, grind up the plants into torn fragments. Peons take this material up in baskets and convey it to pebble mills. These are short iron cylinders which are arranged so as to rotate on their axes. Each mill is lined with flint bricks and is charged with ground shrub, water and coarse flint pebbles which by their impact on each other comminute the shrub and agglomerate the rubber. After

the milling is complete, which ensues after about 3,000 revolutions at the rate of 30 per minute, the mixture of water, comminuted shrub and bagasse is discharged and flows into skimming tanks. In these a portion of the bagasse, consisting of fibrous material (bast, wood) and fragments of other cell walls, sinks, while the agglomerated rubber ("worm rubber"), accompanied by a bagasse composed of minute flakes of cork, floats. This floating mixture can now be separated into practically clean worm rubber and rubber-free bagasse by boiling, and then by submitting it to a pressure of about 250 pounds under water, in order to water-log the cork flakes. A further cleansing of the worm rubber flakes takes place in a tank supplied with a paddle wheel, which beats the floating particles and so rids them of adherent particles. After this there remains but the "sheeting," which is accomplished by passing the worm rubber between corrugated steel rollers to form sheets. It may be packed in sacks in this form or pressed into solid blocks, say, of 50 pounds weight and packed in boxes. In this process it is evident that there are two critical phases, first the agglomeration of the rubber and, secondly, its later separation from the bagasse. The former is relatively easy or difficult, according to the richness of the tissues in rubber, or stated otherwise in the size of the rubber particles within the cells of the tissue. The separation of rubber from bagasse depends on the difference in their specific gravity, using this term in a loose sense. The fibrous elements, namely wood, bast and broken open cell walls, are easily waterlogged—that is, the occluded air is easily dispelled, while the cork is difficult to break up and even more so to rob of its air.

The coarse worm rubber floats rather readily; but the smaller the particles the more slowly they rise to the surface. Any means which may be used to cause a swelling of the particles, or to lessen the distance which they must travel to reach the surface, afford help in attaining to segregation of the rubber. The colloidal properties of rubber make swelling possible by means of any of its solvents. The depths of the tanks which are used for separation of rubber and bagasse is obviously important. When it is known that an extraction of 7 per cent. rubber (of which the moisture amounted to 25 per cent.) was raised during about five years to 15 per cent. by slowly improved methods, we may realize the amount of experiment and ingenuity necessary. It would have been well for the industry to-day if, during the earlier period, there had been less desire to take advantage of the ease of acquiring profit and more study and experiment. To be sure, a good deal of rubber left in the bagasse was later reclaimed, but the total lost in spite of this must have amounted to a good deal. This was, however, only one form of economic waste. By far the most serious lay in the method of gathering the shrub by pulling it up by the roots, called,

however, by the euphonious name of "*cortando,*" or cutting. Had the guayule actually been cut off at the level of the ground, new shoots would have sprung up in many instances to take the place of the removed plants.

Reproduction of the Shrub

It has always been fully realized that the limiting factor of the guayule industry is the rate of growth and of natural reproduction of the "stand," unless the demand for shrub could be met by cultural methods. It is obvious that until the possibilities of culture could have been determined, the proper procedure would have been conservation of the mature supply by forestry methods. We may now examine the guayule plant from this point of view.

Fig. 12. The Annual Accretion of Growth in a Guayule Twig of average rate of growth.

The guayule is a woody shrub which, in common with most desert plants, is of slow growth under normal conditions. It affects the stony or rocky footslopes and foothills of the limestone hills and mountains within a region of uncertain and at best scanty rainfall. Few and imperfect records are available for the guayule region proper, but it is safe to say that the total precipitation does not exceed 10 or 12 inches. The effective rains fall chiefly in summer. The growth season is therefore short and the annual increment in growth in length of branches does not exceed an average of 3 to 5 cm. (Fig. 12). Plants certainly 50 years old do not exceed a meter in height or spread. I have never seen an old plant excelling in both dimensions. By careful measurements of numerous field plants it has been determined that it takes about 10 years for an individual to acquire a weight of about 8 ounces, but in the following five years it will make eight ounces more and will have ar-

rived at an economic maximum. It may then be concluded that assuming an even stand of a ton to the acre, it requires 15 acres to supply one ton a year, allowing for good years and bad. Most guayule land will not yield so well. It is, however, clear that where the land is very cheap and can be used for other profit to a considerable extent without materially damaging the shrub, a conservative method of gathering could have been made to yield reasonable and constant returns.

It has been assumed that the stand is maintained by the reproduction of guayule by seed. Field studies have shown that this is true. Areas of known dimensions have been cleared of all plant growth, and the new seedlings counted; and censuses have been taken of such areas to determine the population of plants of various ages. The information obtained proves clearly that the more usual method of reproduction is by seed. It must be added that different localities often not widely separated show a very diverse efficiency in this regard. Indeed, it has often been difficult to see any evidence that if the present growth were removed there would be any effectual replenishment by seed. Such places are marked by the absence of small seedlings and usually carry only mature individuals of approximately the same size. But it by no means follows that in such situations there is no reproduction at all, for in addition to seedlings the guayule also increases its members by means of "retoños," that is, by new shoots which strike upward from the shallow lying lateral roots. In the course of time retoños establish their own roots and become entirely separated from the rest of the plant and consequently independent organisms. Retoños grow more quickly than seedlings and are more certain of arriving at maturity. Because of the previous establishment of the root they may develop where, on account of slight depth of soil, seedlings would fail. As a matter of fact they are relatively more plentiful on rough stony ground and are particularly prone to occur where the surface of the ground is steep and the roots become exposed by erosion, though this is not a condition necessary to their formation. Furthermore, they develop flowers in the first season of their growth so that, in the event that the guayule were removed they would constitute a pretty certain insurance against extinction.

Whether the cutting away of the aerial portion of the plant induces the growth of retoños or not has not been decided, but, as already said, it is followed by abundant reproduction of new shoots from the stocks left in the soil. These follow cutting in about 40 per cent. of the cases, so far as determined, but as the year when the censuses were made was a dry one the figure is probably low for a good season. The time when the cutting takes place doubtless also influences the result. Aside from this, however, these new shoots develop rapidly, but flower abundantly in the first season and are thus effective in reseeding the ground.

We see, therefore, that the guayule is by no means unequipped for

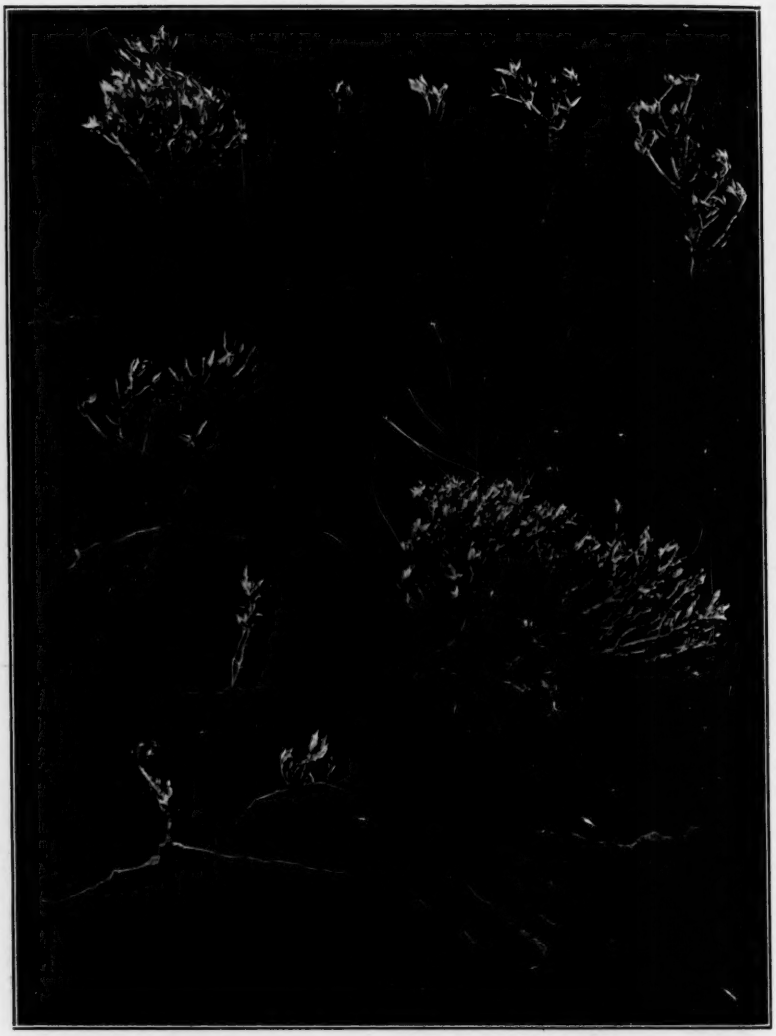


FIG. 13. THE DEVELOPMENT OF THE GUAYULE PLANT FROM SEEDS AND FROM RETOÑOS.

its business of obviating the effects of untoward conditions in its environment. We may now inquire briefly into its response to cultivation.

GUAYULE UNDER CULTIVATION

To introduce a feral plant into a condition of culture is not without much uncertainty as to the results. The physiological balance is frequently so disturbed as to produce marked quantitative changes in the various secretions. Thus it happens that certain drug plants when put under cultural conditions do not always produce alkaloids or other

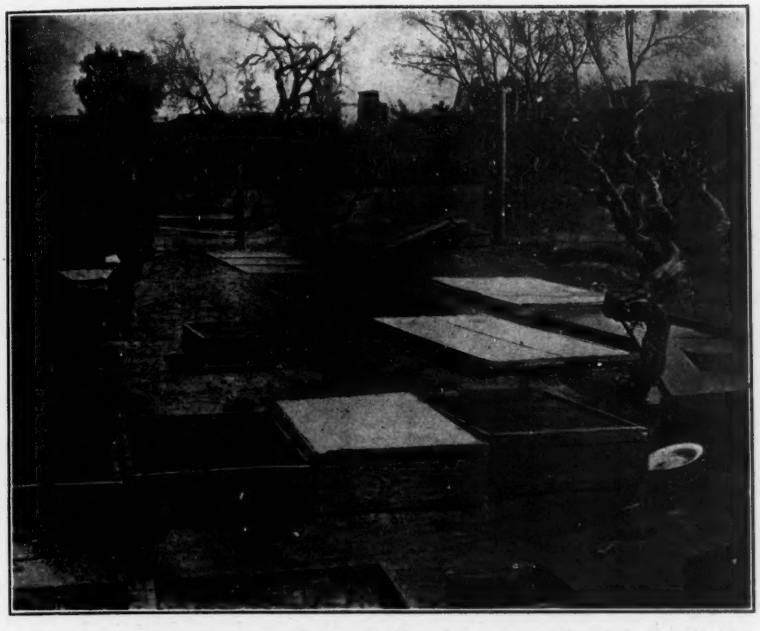


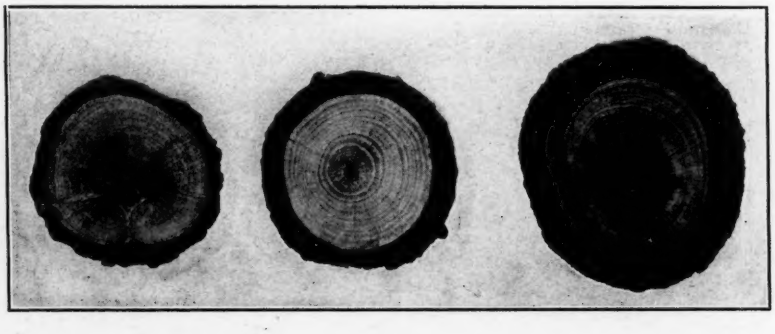
FIG. 14. EXPERIMENTAL GARDEN FOR THE STUDY OF REPRODUCTION OF GUAYULE, STACIENDE DE CEDROS, ZACATECAS.

FIG. 15. GUAYULE UNDER CULTIVATION IN AN EXPERIMENTAL GARDEN AT CEDROS, ZACATECAS, MEXICO.

desired substances in the same amount as in the wild. When the problem of cultivating the guayule presented itself, the first question that arose, and most naturally, was the relation of secretion of rubber to the supply of soil water. Though there is no very good *a priori* ground for expecting one result or the other, it was known that the amount of rubber obtained from certain latex trees is influenced by the amount of soil water during the period of tapping. It was also found that in the guayule the occurrence of rubber in the new growths of the particular season intervenes only after a distinct interval of time, for which reason the collecting of the shrub at the close of the rainy season involves a great waste, since the increased weight is in no degree to be referred to a greater rubber content.

The careful study of the guayule plants which were under cultivation and had been freely irrigated developed, in addition to several other points of interest, the knowledge that the greater the amount of growth (itself dependent on the amount of water available), the slower the secretion of rubber and the smaller its total amount relative to the volume of the tissues. On the other hand, the rate of growth under irrigation is so much more rapid that the total volume of rubber-bearing tissue is very greatly in excess of that in field plants. Irrigated plants present other features of difference which must be taken into account by the manufacturer and which are of very great interest to students of the physiology of desert plants. I need mention only the more salient here, namely, the greater relative volume of the woody portion of the stem, its harder and more rigid character, the smaller volume of the cortex (bark) (Fig. 16) and the quantity of rubber in individual secreting cells.

The increased hardness of the "wood" in the irrigated plant is due, in part at least, to the reduced volume of the medullary rays. And as



a *b* *c*

FIG. 16. TRANSVERSE SECTIONS OF GUAYULE STEMS, of the same transverse area of wood, grown under irrigation (*a*) and wild (*b*, *c*). *c* was from a plant of unusually rapid growth.

these make up a goodly proportion of the volume of the smaller twigs in the field plants, and since the medullary ray cells contain rubber, the greater hardness of the irrigated wood is attained at the cost of rubber-bearing tissue. The lessened volume of the cortex and of the pith contribute to the same results, so that even if the amount of rubber secreted by the individual cells remained unaffected by irrigation, the amount relative to the volume of the plant will be materially less. But so far as the writer's own observation goes the rubber cells in the plants which have been abundantly watered so as to extend the growing season over six or seven months, do not, even after subsequent sustained drought periods, contain the normal but rather a considerably less amount of rubber. This, from the point of view of the manufacturer, means that the globules of rubber which must be agglomerated into worm rubber in the pebble mill are smaller and farther apart and consequently more difficultly brought together. It means, too, that in obtaining a given amount of rubber much more bagasse must be handled. These difficulties may doubtless be overcome by suitable modifications in the details of the process already outlined.

The reader will have gathered the impression that the guayule may be grown readily under cultivation. This is true, at least in its areas of distribution and in adjacent or other areas of similar meteorological conditions. It does not, however, thrive in eastern Texas, judging from a specimen planted by Dr. H. H. York at Austin, nor in Alabama. Here it will grow rapidly the first season, but little the second. Further, a large percentage of the plants are killed by frost and dampness combined, whereas they will resist severe frost in dry regions. And again the amount of rubber in them is very small indeed. Why this peculiar relation of rubber secretion to soil water can not be said. The teleologist will doubtless see in rubber a means adapted to conservation of water in the desert plant. Field guayule, however, wilts almost immediately upon being pulled up, and its congener mariola, which is more drought-resistant, has even less rubber than irrigated guayule.

On the other hand, the larger development of the wood appears to be correlated with a more rapid growth, and consequently a larger production of leaves, made possible by a greater water supply. This logic is clearer when it is realized that the wood contains the water-carrying vessels and at the same time the mechanical tissue for the support of the foliage. From this point of view the more extensive rubber-bearing tissues and apparently greater succulence in field plants result from more meager development of the wood and do not speak for a larger "water balance," one criterion, at least, of drought resistance.

One additional feature of the behavior of guayule under irrigation, especially when grown from transplanted stocks, is worth mentioning in closing. It had been noticed that its congener, the mariola (*Par-*

thenium incanum), does not produce retoños, as does the guayule, but sends up each season new shoots from the base of the trunk. These shoots root independently and in the course of events are separated by a constriction of the connecting tissue from the parent plant so that an old mariola plant is really a cluster of partially or wholly independent individuals. Such behavior is absent from guayule under normal conditions, but may be readily induced under irrigation, and in this way there is afforded the means of vegetative propagation which stands in lieu of the usual method of making cuttings, which has not been found possible up to the present.

The question which many will ask, whether it will pay to cultivate guayule, must remain, for the present, unanswered. That guayule may be propagated under cultural conditions, both by seed and vegetatively, has been demonstrated. That there are immense areas adapted to guayule and now almost profitless is almost equally sure. The problem seems to be how to get the plant started and to determine to what extent temporary irrigation, by manipulation of the run-off, will be justified on practical economic grounds. An experiment of large scope could be conducted so as to answer these questions and might reveal a new means of increasing our resources.

ROUSSEAU'S CONTRIBUTIONS TO PSYCHOLOGY, PHILOSOPHY AND EDUCATION

By Professor W. B. PILLSBURY
UNIVERSITY OF MICHIGAN

AS is often the case with a great man viewed two centuries after his time, one is tempted to wonder what the source of Rousseau's repute may have been. Few men have so greatly influenced the course of thought in many different directions as Rousseau and few great men have been as little worthy of influence, judged by their characters or their attainments. It seems incredible that a vagabond, a psychopath, a man without serious training, should produce a system of philosophy, a system of education, a political philosophy, that was to modify the political systems as well as the course of thought of civilized nations for generations. To repeat a few cant phrases, Rousseau offers a paradox in each of his capacities between his theories and his actions. He preached social cooperation and the acceptance of social responsibilities, but was himself a hermit and recognized a duty only to avoid it; he praised social equality and the advantages of limiting one's desires rather than seeking means of satisfying them, but he spent his life fawning upon the great and the wealthy, and was always a parasite upon some one more fortunate than himself; in his system of education he gives much space to arguing the advantages of personal parental care for children, while he sent his own five children as soon as born to a foundling asylum, and with so little care that no one was able to trace them. Apparently the father was never sufficiently interested in their fate to make the attempt. The list might be expanded indefinitely, but this will amply suffice to show the inconsistencies of the man.

The key to his inconsistencies as to much of his power as a writer is to be found in his mental abnormalities. He was undoubtedly a psychasthenic all his life, and in his last years this probably passed over into insanity. The symptoms of psychasthenia are clear throughout his confessions. He was tortured always by the delirium of doubt, he was often aboulic, the sexual life that he portrays so fully gives much evidence of a Freudian neurasthenia; in his later life he was never without delusions of persecution. Nothing is lacking to complete the clinical picture. As one result of his mental disease he was never in complete control of either thought or action. He never could definitely and sharply pass upon the truth or falsity of his ideas. He lived all his life in a half-dream state, incapable of saying whether any one of the trains of ideas that presented itself was quite real, or was consistent with any other. To change the metaphor, his was a play life, through-

out. Each book and each chapter, even, of a book was a separate game with little relation to any other book or chapter or to the world of reality. It was consistent with that part, but had little or no relation to any thing beyond. He never grew up. In consequence he was never burdened by the adult necessity for consistency. Any act or any thought was true for the moment, and that was as far as he was capable of judging. The extent to which writing was a game for him is well illustrated, if we may believe Diderot, by the way he decided to take the most important stand of his life, that against art and science and all departures from nature. Diderot asserts that when Rousseau saw the topic that had been announced by the academy of Dijon in competition for a prize "Whether the progress of science and the arts had contributed to corrupt or improve morals," he was on the point of taking sides in favor of the arts and sciences. When, however, Diderot pointed out the advantages of taking the more striking position, he at once accepted it, and the "Discourse upon Science and Arts" was the result. This of course was the key to all of his later writings. It is fair to say that his whole system took its rise in a chance remark, and was the outcome of a desire to attract attention rather than of any high moral purpose.

As a writer and thinker this mental defect had its points of advantage to him. Any thought that occurred to him was given full expression. He need feel no restraint from facts. A half truth was as good as a whole truth, provided only it be picturesque. He could work out a line of thought as in a dream and publish it without feeling the paralysis of the demand for consistency. When the next thought presented itself he need not reject it because it was incompatible with his last publication. As a psychasthenic he was probably incapable of passing upon the truth or consistency of his ideas. He could believe each in turn with all the fervor of his nature, and work it out to its full logical conclusion with no regard for anything else.

Rousseau is one of the best instances in support of the theory that genius is allied to insanity. He illustrates at once the strength and the weakness of the insane type of genius. He was full of new and original ideas that found room to germinate uncontrolled and unchecked by any rational considerations of mutual compatibility and truth. Friend and foe find in these characteristics the basis of adoration and criticism. In the riot of opinion each reader can find what appeals to him. He suits all, as does the phrenologist with his patter. Each can select what seems true to him and overlook or forget the rest. Thus Kant could find in his writings the seeds of his categorical imperative, as truly as the leaders of the Reign of Terror could find support for their excesses. Pestalozzi drew from him justification for discarding all that was in books, while the literary leaders of the enlightenment were inspired to

return to classical models. While the man who goes to him in a sympathetic spirit finds in him a seer with inspiration for every different mood, the critic who looks to see what his teaching really is finds that there is on every point not one opinion, but several, that there is nowhere consistency, and when comparison is made between precept and act he finds every reason to suspect insincerity. The opposing theories are reconciled, however, when we recognize that we are dealing with an unstable nervous system, that Rousseau was not competent to coordinate and test his theories, nor to exert full control over his acts. His theories are dreams, his acts are the acts of a somnambulist. They should not be judged by the ordinary standards.

Enough of the psychology of Rousseau: our real question is, what did Rousseau contribute to psychology? This is somewhat difficult to answer. His specific contributions are practically *nil*. The psychology that he uses in his writings is varied. Passages in the Émile are evidently taken almost verbatim from Condillac, other passages he evidently owes to Descartes, while still others show the influence of Locke. In no place does he develop any important views of his own or even harmonize those that he borrowed. He had no followers in psychology. One can point to no one who was distinctively a psychologist that owes much to Rousseau. His strongest influence has been very recent and very indirect. Through his educational teachings that instruction should be based upon a knowledge of the child, he has perhaps had some small part in stimulating the studies of childhood that have been made in the past few decades.

Rousseau's greatest contribution to psychology is probably the raw material that he provided in his Confessions. No one else has attempted to lay bare the innermost secrets of his life in the same degree. Were it to be worked over carefully there is undoubtedly much of great value. Even this however suffers from two drawbacks. It is written for the most part so long after the events that it is probably inaccurate. It is rather Rousseau's theory of what his life should have been when viewed from near its close than a real account of the life itself. The second difficulty is the pathological character of the material. It has furnished much material or at least many illustrations to the psycho-pathologist, but the student of the normal mind must take all the statements with caution.

If Rousseau's influence upon psychology was negligible, his influence upon philosophy was of great importance. His greatest contribution to that discipline was through his effect upon Kant. Little as there seems to be in common between the stern German rationalist and the unbalanced French enthusiast, there is much to indicate that Rousseau affected Kant's general ideas in no inconsiderable degree. Of common knowledge is the story that Kant gave up his daily walk to read

the Emile, and thereby caused perturbation in the minds of the burghers accustomed to set their watches by the habits of the philosopher. Kant himself bears witness to the fact that Rousseau and Hume were the two thinkers who had most profoundly influenced him, and Rousseau's portrait was the one ornament of his study. The personal admiration of Kant for Rousseau was undoubtedly profound.

When we turn to discover specific evidence of the presence of Rousseau's theories in Kant's writings, the task is not so simple. Kant was in no sense a disciple of Rousseau. Authorities differ widely as to how much and what shall be assigned to Rousseau, from the general plan of the three critiques to a few specific elements in the ethics. There seems to be good evidence that Kant became interested in the problems of man soon after he read Rousseau, or, as another puts it, that he took from Rousseau his tendency to a democratic as opposed to an aristocratic basis for morals. Wenley suggests that much of Kant's theology may be found in "The Confessions of Faith of a Savoyard Vicar" and the corresponding fourth book of Émile. Dieterich puts the emphasis upon the similarities in the ethical systems, and would trace the categorical imperative to Rousseau's doctrine of conscience and his general tendency to find the seat of authority in man's own nature. Superficially regarded, there seems little similarity between anything in Rousseau and the categorical imperative, but careful historical examination makes a fair case for their kinship. Thus we find several points at which the half-mad and altogether irresponsible Frenchman supplied grist for the mill of the most staid of modern German philosophers.

The influence of Rousseau upon Fichte and Schelling, both directly and indirectly through Kant, was also considerable. We can not go into details in the time at our disposal, but it is not too much to say that it is possible to trace the influence of Rousseau's spirit and some of his specific theories through a large part of modern philosophy.

It is in education, however, that Rousseau's theories have been most important. In later educational writers, we can find not merely possible traces of his way of thinking, but we can find his theories restated over and over, often without credit, and always thinly veiled. Most of the current educational theories can be matched in Rousseau. The doctrine of interest, that a child should learn only as he becomes interested, is Rousseau's. We find fully developed in him the culture-epoch theory and the doctrine of discipline by natural consequences usually credited to Spencer. The reaction from mere book knowledge was also made much of. Émile, it will be recalled, was not to know how to read at twelve and then was to acquire knowledge at first hand as much as possible. It is to Rousseau that we owe our vocational units. Rousseau's doctrines contributed largely to the development of later systems. Pestalozzi and Froebel drew inspiration directly from him, and Herbart

owes much to him. Herbert Spencer also shows his influence indirectly, although he had not read Émile when he wrote his essay on education. For good or for ill, then, the popular educational doctrines of the day can be traced to Rousseau.

In brief, Rousseau had an important place in both philosophy and education. It would be interesting to ask how many of Rousseau's doctrines were his own and how many were merely borrowed and worked over. Many of his theories can be traced to earlier men, to Montaigne, to Rabelais, to Montesquieu. His educational theories were largely modified from Locke and Condillac, and the influence of the classics was great in all departments. Much more was common thought and common talk among his associates—what might be called the spirit of the age. What there is left that is original is difficult to say. Certainly, nowhere else among the writers of the age have these ideas been brought together and put with such emotional fervor and literary skill. Whoever may have originated the ideas, Rousseau gets credit for them because of his skill in exposition. Certainly no one better than he represents all the contradictory tendencies of his age.

Still another question presents itself in connection with a man like Rousseau. Does he deserve any credit for his ideas? They present themselves in striking profusion in a highly unstable nervous system, ideas, good, bad and indifferent, queerly assembled and altogether out of relation to each other and to the acts of the man himself. It may even be questioned whether Rousseau was able to distinguish between the true and false, the worthy and the unworthy. Each was given expression with no reference to anything else or to its value. There was apparently no definite purpose in their utterance, aside from pleasing the reader or satisfying the artistic sense of the writer, there was even no responsibility for them. It might be asked in retort how far any one deserves credit for his ideas, and how many men have been able accurately to guage the value of their contributions. Rousseau furnishes an enigma in this respect, but all questions of credit in this fundamental sense are enigmatical. Certain it is that an occasional unstable nervous system of this sort is likely to be a spot where ideas of value germinate and makes for progress in the world of thought. Whether Rousseau is to be regarded as a credit or debit on the world's books depends upon the point of view. The relatives of the victims of the Reign of Terror would give one answer; you would get another if you asked the men of all ages who have enjoyed the brilliant literary work of Rousseau or the increasing democracy that followed the French Revolution, assuming, which is an open question, that Rousseau was really responsible for the economic change.

SMOKING AND FOOTBALL MEN

By Dr. FREDERICK J. PACK

UNIVERSITY OF UTAH

WITHIN recent years several investigations have been made concerning the effect of smoking on college students, but in the opinion of the present writer the bases upon which conclusions were founded were often of such a nature that the results were more or less indefinite and unreliable. It has been very difficult to segregate the effects of smoking from other factors, particularly those of physical fitness and of social environment. In most, if not all, of these investigations, all classes of students have been included, ranging from the typical scholarship men to those who are in attendance, largely because of participation in athletic sports. Students of different ambitions, of different social classes, of different methods of living have been considered alike in one great group in such a way that the results were often susceptible of various interpretations.

In order satisfactorily to arrive at a definite conclusion concerning the effect of smoking an investigation should include men alike in physical and mental aptitude, except as modified by the use of tobacco. In general the men should be equal in physical fitness; it is manifestly undesirable to compare recluse scholarship men with those who are in attendance largely because of athletics. If such a heterogeneous group of men were examined with respect to scholastic standing the athlete would unjustly suffer, while if the same group were examined with respect to athletic attainment the injustice would fall upon the scholarship man, as it is quite generally recognized that the percentage of smokers is higher among athletes than among scholarship men. So far as possible the men should be alike in social tendency, as activity in social functions tends toward smoking and low scholarship. The socially inclined student, therefore, is likely to be a smoker and to belong to the low-scholarship group, but whether his low scholarship is due to his smoking or to his social tendency is difficult, if not impossible, to decide. In the main, therefore, the students under investigation should be either scholarship men or athletic men; they should be participating in the same kind and amount of athletic sport; they should be carrying the same amount of scholastic work; they should be taking part in the same kind of social activities.

While it is not claimed that all of these disturbing factors have

been eliminated in the investigation about to be described, yet it is confidently believed that several of them have been largely avoided. It is difficult if not impossible to obtain a large group of men conforming in detail to the requirements above outlined, yet the closer such a group is approached the more reliable will be the results.

It occurred to the writer some three years ago that the football squad forms a very nearly homogeneous group. In the first place, the men are all athletes approaching physical perfection, a fact which tends to unify their mental attitude as well as their physical. Of recent years the eligibility rules have made it well-nigh impossible for transients and low scholarship men to "make the team," the regulations requiring the men to carry full courses not only during the year of participation, but also during the previous year. Socially the football men are much more alike than any group promiscuously gathered from the student body.

It is quite apparent that reliable conclusions can not be drawn from the records of a single football squad. Two years ago a few of the athletic directors in institutions in the inter-mountain states were asked to submit data relative to their football men, of course stating whether they were smokers or non-smokers. The results were very interesting and suggestive, but the number of men concerned was still rather small.

At the beginning of the present school year (1911–12) a much larger number of institutions were asked to assist in the investigation by submitting data. The following facts are based upon information received from coaches and athletic directors of fourteen American colleges and universities. The writer is fully aware of the fact that the varying conditions of the schools may introduce errors, yet they have carefully been guarded against and largely eliminated in the final summaries.

The blank forms sent out to the various athletic directors provided for the following data: age, weight, ordinary anthropometric measurements; ability on the team, whether fair, good or very good; scholastic standing of last year, including average scholarship mark, and number of conditions or failures; the number of smokers and non-smokers who attempted to "make place" on first team together with other more or less important features. The students were also to be designated as "smokers" or "non-smokers." The following foot-note appeared on each blank: "By 'smoker' is meant one who habitually smokes when not in training and not an individual who indulges at very infrequent intervals." It was thus desired that only habitual smokers be included in the list, as it is quite generally agreed that the infrequent use of tobacco is not seriously injurious.

It will not be possible to include a constant number of institutions or men in each of the various items following, as the blanks which were returned were only partially filled in; some of the institutions supplied

one series of data and some another. In the item of "try outs" six institutions reported on 210 men; in the item of "smokers or non-smokers" fourteen institutions reported on 248 men; in the item of "weight" fourteen institutions reported on 237 men; six institutions reported 108 men with respect to "lung capacity"; while fourteen institutions reported on 182 men in the item of "average scholarship mark." In each of the items following the number of men involved will be designated and also the number of institutions from which they are reported.

As just stated, six institutions furnished data relating to the "try outs." A total of 210 men contested for positions on the first teams; of this number 93 were smokers and 117 were non-smokers. Of those who were successful 31 were smokers and 77 were non-smokers. The following tabulation will make this matter clear.

TRY OUTS

	No. Competing	No. Successful	Per Cent. Successful
Smokers	93	31	33.3
Non-smokers	117	77	65.8

Six institutions reporting.

It will be observed that only half as many smokers were successful as non-smokers. At first thought this point may appear to be at variance with the findings of Dr. Meylan at Columbia University. Under the title "The Effects of Smoking on College Students," published in this magazine for August, 1910, Dr. Meylan makes the statement "that 41 per cent. of the smokers and only 34 per cent. of the non-smokers achieved success in varsity athletics." This statement of course tells nothing unless the exact number of smokers and non-smokers who actually tried for places in the "varsity athletics" be given. It may be that only a very small percentage of the non-smokers contested for positions and that practically all who did so were successful, while on the other hand that a much larger percentage of the smokers made the effort and a comparatively few were successful. In such a case the actual number of successful smokers might be larger than that of the non-smokers, and at the same time the percentage of the successful smoking contestants might be very much smaller than that of the non-smoking contestants. Consider the following case. Suppose an institution in which there are 400 men, 200 smokers and 200 non-smokers. Suppose that 150 of the smokers contest for positions and that 33.3 per cent. (50 men) are successful. Suppose further that only 50 of the non-smokers contest for positions and that 66.6 per cent. (33 men) are successful. In this case 25 per cent. of the total number of smokers

and only 16.6 per cent. of the non-smokers obtained places on the varsity teams. It is clear from the above that the concluding sentence means nothing unless the number of smokers and of non-smokers contesting is given.

The conclusion that smokers stand but little chance with non-smokers in obtaining places on football squads is not only shown by the total of the six institutions, but is similarly shown in each of the six. It should be observed here that the introduction of data from a single institution departing radically from the general trend of all others would influence very largely the average of the total. In such a case the average would be wholly unreliable. But in the case at hand where not only the total of the six institutions point in a given direction, but also each of the six, the average very closely approximates the truth.

The following table shows the inferiority of the smokers in each of the six institutions reporting:

	Number Competing for Places	Number Successful	Per Cent. Successful
Institution A.			
Smokers	11	2	18.2
Non-smokers	19	11	57.9
Institution B.			
Smokers	10	4	40
Non-smokers	25	17	68
Institution C.			
Smokers	28	7	25
Non-smokers	17	14	82
Institution D.			
Smokers	28	11	39.3
Non-smokers	15	10	66.6
Institution E.			
Smokers	10	7	70
Non-smokers	15	12	80
*Institution F.**			
Smokers	6	0	0
Non-smokers	26	15	57.7

The following table gives the names of the institutions reporting and the number of smokers and non-smokers in each. Very incomplete data were submitted by three other institutions, two of which appended notes to the effect that the information was not wholly reliable. In the third institution the football squad contained no smokers. It may be well to state that the University of Utah is not included in any of the computations, as the team contained no smokers and, further, none of the men who tried for positions were smokers.

* It will be noted that no smokers obtained places on this team. In consequence of this the data from this institution are not used elsewhere in this investigation.

Institution	Smokers	Non-smokers	Total
Amherst College	9	9	18
Drake University	2	9	11
Haverford College	4	17	21
Michigan Agricultural College	3	14	17
Northwestern College	12	5	17
Tulane University	7	14	21
U. S. Naval Academy	7	5	12
University of Colorado	5	7	12
University of Kansas	10	9	19
University of Montana	12	7	19
University of Pennsylvania	12	12	24
University of Tennessee	11	10	21
Western Maryland College	7	12	19
Yanktown College	8	9	17
	109	139	248

Of the total number 44 per cent. are smokers and 56 per cent. are non-smokers. Of 213 students examined by Dr. Meylan at Columbia University 52 per cent. were smokers and 48 per cent. were non-smokers.

From the following tables it will be observed that the two classes of men are of practically the same age and weight.

	No. of Men	Combined Age	Average Age
Smokers	103	2,164 years	21.01 years
Non-smokers	134	2,821 years	21.04 years

Fourteen institutions reporting.

	No. of Men	Combined Weight	Average Weight
Smokers	103	16,645 lbs.	161.5 lbs.
Non-smokers	134	21,579 lbs.	161.0 lbs.

Fourteen institutions reporting.

While the differences in age and in weight are very slight, it should be noted that they both are in favor of the smoker. This point will be considered later.

The following table shows the relation between smoking and lung capacity.

	No. of Men	Average Weight	Average Age	Average Lung Capacity
Smokers	47	162.9 lbs.	21.06 years	286.3 cubic inches
Non-smokers	61	159.6 lbs.	20.88 years	308.9 cubic inches
Difference		3.3 lbs.	.18 year	22.6 cubic inches

Six institutions reporting.

It will be observed that smokers of the same age as non-smokers and 3.3 pounds heavier have a lung capacity of 22.6 cubic inches (7.3 per cent.) smaller. Inasmuch as the smokers are heavier than the non-

smokers by 3.3 pounds, their lung capacity should, from the standpoint of averages, be correspondingly greater. The following computations are based upon the weight and lung capacity of the non-smoker:

Non-smoker's lung capacity at 159.6 pounds is 308.9 cubic inches.
Smoker's lung capacity at 162.9 pounds is 286.3 cubic inches.
Smoker's lung capacity at 162.9 pounds should be 315.3 cubic inches.
Smoker's loss in lung capacity is 29.6 cubic inches, or 9.4 per cent.

In the item of lung capacity, it appears that the effects of smoking are almost completely segregated from those of other factors. The habit of smoking here stands strongly indicted. The evidence becomes little less than proof conclusive when it is noted in the following table that the smokers show a decided loss of lung capacity in each of the six institutions reporting.

	Average Weight Lbs.		Average Lung Capacity Cu. In.	Loss in Lung Capacity Cu. In.
Institution A.				
Non-smokers	161.8		289.1	
Smokers	167.4		284.3	
Smokers at	167.4	should have	299.1	14.8
Institution B.				
Non-smokers	161.3		287	
Smokers	166.8		291	
Smokers at	166.8	should have	296.8	5.8
Institution C.				
Non-smokers	159.7		357	
Smokers	156		336.6	
Smokers at	156	should have	348.9	12.3
Institution D.				
Non-smokers	170.2		333.8	
Smokers	175.3		313.0	
Smokers at	175.3	should have	343.8	30.8
Institution E.				
Non-smokers	149.3		296.7	
Smokers	152.5		264.3	
Smokers at	152.5	should have	303.0	38.7
Institution F.				
Non-smokers	157.7		278	
Smokers	158.7		268.1	
Smokers at	158.7	should have	279.8	11.7

The athletic directors of the various institutions were asked to divide their men into the classes, fair, good, and very good. This classification was to be based upon the ability of the men as all round football players. The following table shows the distribution of the men according to the rating of their coaches:

	No. of Men	Fair	Good	Very Good
Non-smokers	139	68	50	21
Smokers	109	49	39	21
109 non-smokers would furnish		53.3	39.2	16.5
Smokers' excess		—4.3	0.2	4.5

From these data it appears that smokers make the better football players. In interpreting the results, however, several points should be kept in mind. In the case of the "very good" men only forty-two individuals are involved, a number rather small from which to draw reliable conclusions. A single institution reporting four or five "very good" smokers or non-smokers and none of the other group (as several institutions have done) is quite sufficient to swing the totals one way or the other. And again, while the totals from the fourteen institutions seem to favor the smokers, this is by no means uniform when the institutions are singly considered.

Even if the above data were perfectly reliable there is still another vital point to be kept in mind. In the item of "try outs" only half as many smokers were successful as non-smokers. In other words, only the very best smokers were chosen, while with the very best non-smokers a group of second-grade non-smokers was included. At the beginning of the football season when the selections were made the first and second grade non-smokers combined were equal to the first grade smokers.

Furthermore, it is a well known fact that of two men, a smoker and a non-smoker, of equal ability at the time of beginning training, the smoker will develop into a better man than the non-smoker. This is the case because the non-smoker before training is very much more nearly at his best than is the smoker. As soon, therefore, as the smoker begins training (and consequently stops using tobacco) he has a much better chance for improvement than the non-smoker, who has not been kept back by the use of tobacco. If smoking does not in any way injure one's ability on the football field, the smokers and the non-smokers should supply an equal percentage of the "very best" men.

Now, when it is borne in mind that in the "try outs" only one half as many of the smokers are chosen as non-smokers, it follows as a simple mathematical deduction that the smoking football men should supply twice as many "very good" men as the non-smokers, a position which, if the above tabulated data were wholly reliable, they come far from reaching. It will be noted, therefore, that the apparent superiority of the smokers is in reality an inferiority.

In this connection reference may profitably be made to the item of weight given in a previous table, in which it will be observed that the smokers are one half pound heavier than the non-smokers. At first thought this point may appear to be in conflict with the findings of Dr.

Seaver at Yale University,[2] where it was shown that the non-smokers were three pounds heavier than the smokers. The excess weight of the smokers is readily accounted for when it is remembered that in the "try outs" only one third of the smokers were successful, against two thirds of the non-smokers. In football, where the factor of weight plays an important part, it is quite apparent that the larger men are more likely to be selected than the smaller ones. If, however, in the "try outs" an equal percentage of the smokers and non-smokers were chosen the results would in all probability not be out of harmony with those of Dr. Seaver.

In the following the scholastic standing is shown.

	No. of Men	Total Mark	Average Mark
Smokers	81	6,034	74.5
Non-smokers	101	8,021	79.4

Twelve institutions reporting.

It will be observed that the smokers average 4.9 per cent. below the non-smokers. This average alone, however, is not wholly reliable, as the standards of marking in the various schools are by no means uniform—an individual in one institution might be ranked at 75 per cent., while in another institution this same student might be ranked at 90. From the following table, however, it will be observed that the smoker is inferior in *each of the twelve* institutions reporting, a fact, of course, which strongly corroborates the above averages.

Institution	Smoker	Non-smoker	Institution	Smoker	Non-smoker
A	65.2	69.8	G	74.0	75.0
B	64.7	74.6	H	75.2	79.4
C	78.8	81.1	I	81.6	88.4
D	75.8	77.6	J	78.5	81.3
E	84.6	84.8	K	74.0	84.6
F	69.6	71.3	L	77.3	77.6

In each of the twelve institutions reporting scholastic standing the highest and the lowest marks were tabulated for the smokers and non-smokers. The results follow:

	No. of Men	Highest Marks	Lowest Mark
Smokers	81	4	12
Non-smokers	101	11	6

Based on equal numbers of men the results would be as follows:

	Highest Marks	Lowest Marks
101 non-smokers furnish	11	6
101 smokers would furnish	5	15

[1] See *Arena*, for February, 1897.

Smokers would accordingly furnish 71 per cent. of the lowest marks, and the non-smokers only 29 per cent. The smokers would furnish 31 per cent. of the highest marks, and the non-smokers 69 per cent.

The combined conditions and failures of the two classes of men are shown in the following table:

	No. of Men	Total Conditions and Failures	Average
Smokers	82	70	.853
Non-smokers	98	43	.439

The smokers furnish twice as many conditions and failures as do the non-smokers.

The following suggestive points are brought out in this investigation:

1. Only half as many smokers as non-smokers are successful in the "try outs" for football squads.

2. In the case of able bodied men smoking is associated with loss in lung capacity amounting to practically ten per cent.

3. Smoking is invariably associated with low scholarship.

THE MINISTER'S SON

By The Rev. CLARENCE EDWARD MACARTNEY, M.A.
PATERSON, N. J.

A FEW months ago, Woodrow Wilson, governor of New Jersey, stood in the little bedroom of the Presbyterian manse at Caldwell. The reason for his pilgrimage to that village and to that particular house was the fact that there Grover Cleveland, the twenty-second and twenty-fourth president of the United States, was born, March 18, 1837. Woodrow Wilson, himself the son of a Presbyterian minister, at Staunton, Va., paid a visit to the Presbyterian manse at Caldwell, out of which came a famous son. The one, now gathered to his fathers, was an oracle of the democracy, and the other is a possible democratic successor to Grover Cleveland at the White House.

The meeting of their paths at Caldwell is suggestive. Both were sons of the manse. It brings up the old question about the character of ministers' sons. Are they all sons of Belial? Are they all base fellows like the sons of Eli and Samuel? Are there none among them who do not belong to the order of Hophni and Phineas?

Charles Lamb wrote a number of essays on popular fallacies. Among the fallacies which he exposed are the following: "That a bully is always a coward"; "that you must love me and love my dog"; "that we should rise with the lark and lie down with the lamb"; "that ill-gotten gains never prosper," and "that enough is as good as a feast." We could wish that he had added one more—that ministers' sons are generally scoundrels. A long time ago Thomas Fuller wrote:

> There goeth forth a common report, no less uncharitable than untrue, as if clergymen's sons were generally unfortunate like the sons of Eli, dissolute in their lives and doleful in their deaths.

He goes on to make due allowance for "Benjamins" among the sons of ministers, that is, sons of their old age, and hence, "cockered" and humored by their ancient sires. But his conclusion is that "clergymen's children have not been more unfortunate, but more observed than the children of the parents of other professions." This last observation, coupled with a possible desire to disparage the ministry, is the sole basis for a gross fallacy, as contrary to reason as it is contrary to fact. We can all think of ministers' sons who were scallawags, no credit to a minister or to any other man. But if the general moral and intellectual standard of ministers' sons is not high, then all principles of heredity, education and environment are overthrown. Adam begat a son in his own likeness, and most ministers do the same.

The clerical family has ever been one of the chief glories of protestantism. We have no thought of opening an old discussion concerning the differing opinions of two great branches of the Christian church. It may be that the voluntary celibate may rise to a higher plane of sacrifice and devotion than the minister with a family. There have been eminent protestants who have renounced the right of marriage. Among them we find such names as Archbishop Leighton, Samuel Hopkins, William Muhlenberg, author of "I would not live alway," and the historian Neander. Suffice it to say that the reformers can not have been unmindful of the example of the patriarchs, priests and prophets of the Old Testament and the apostles of the New Testament. Peter was married, at least he had a mother-in-law, and Paul claimed the right to do as Peter had done. With this ancient precedent and sanction the reformers can not have been much troubled in conscience when they departed from the rule of one man, Hildebrand, and took to themselves wives. Luther must have had more serious reasons for renouncing the state of celibacy than those which he himself gives, viz., to please his father, tease the Pope and vex the devil. At all events, his home life was bright and happy, an earnest and a type of the clerical family life which he did so much to found. His letters to his children are models of what a father's letters to his children ought to be. Calvin was perhaps more discreet in his marriage than Luther. He may have been thinking of the sneer of Erasmus.

Some speak of the Lutheran cause as a tragedy, but to me it appears rather as a comedy, for it always ends in a wedding.

When Calvin married a demure widow of Strassburg, he could still make his boast that he had not assailed Rome as the Greeks assailed Troy, for the sake of a woman. That these early reformers succeeded in harmonizing the life of the priesthood with the life of the family has been for the glory of the church and the untold enrichment of civilization.

The minister's home is usually a home of intelligence and refinement without that ease and luxury which sap the foundations of character. His home is an answer to a wise man's prayer, "Give me neither riches nor poverty." He never gets riches, sometimes he gets poverty, but more often the lines fall unto him in the pleasant places which lie between those two extremes. However limited, the library of the minister's son will have those few books which have been the inevitable companions of genius and attainment—Plutarch's Lives, Pilgrim's Progress, Æsop's Fables, and the Bible. The son of the minister lives in an atmosphere of moral earnestness, intellectual activity and sacrifice and service for that which is highest. If any home ought to send forth a goodly line of stalwart sons it is the home of the minister.

Oliver Goldsmith, himself a minister's son, opens the "Vicar of Wakefield" with these words:

I was ever of opinion that the honest man who married, and brought up a large family, did more service than he who continued single and only talked of population; from this motive I had scarcely taken orders a year before I chose my wife as she did her wedding gown, not for a fine glossy face, but for such qualities as would wear well.

With such serious purpose and intent the founders of clerical households have exalted religion and adorned society. Goethe, when a young man, fell in love with Frederike Brion, the attractive daughter of the pastor at Sessenheim. It was the purest and strongest love of his passionate career, and his intimate knowledge of the life of that clerical household led him to write:

A Protestant country pastor is perhaps the most beautiful topic for a modern idyl; he appears like Melchizedek, as priest and king in one person. He is usually associated by occupation and outward condition with the most innocent conceivable estate on earth, that of the farmer; he is father, master of his house, and thoroughly identified with his congregation. On this pure, beautiful, earthly foundation rests his higher vocation: to introduce men into life, to care for their spiritual education, to bless, to instruct, to strengthen, to comfort them in all the epochs of life, and, if the comfort for the present is not sufficient, to cheer them with the assured hope of a more happy future.

"The one idyl of modern life" Coleridge termed the ministerial family life, and Wordsworth thought it worthy of praise in his "Ecclesiastical Sonnets," where he sings,

A genial hearth, a hospitable board,
And a refined rusticity, belong
To the neat mansion, where, his flock among,
The learned Pastor dwells, their watchful Lord.

In 1750, Justus Möser calculated that in the two centuries after the reformation, more than ten millions of human beings in all lands owed their existence to the clerical family. In the century and a half since he made his estimate the number have very likely trebled. And what influence have these millions of ministers' children exerted upon civilization? To judge of this a brief study of eminent names in Protestant countries is most illuminating.

In the "Dictionary of National Biography," England, there are 1,270 names of eminent men who were sons of clergymen. There are 510 names of famous men who were sons of lawyers, and 350 who were sons of physicians. In this single compilation of great names in English history there are 410 more sons of ministers than sons of doctors and lawyers together. In a recent issue of "Who's Who," for America, out of nearly 12,000 names, almost 1,000 are sons of clergymen, a number out of all proportion to the whole number of ministers in the population of the country. According to that standard, there should have been not more than fifty of these famous men the sons of clergymen.

Time would fail to tell of all the notable men in all departments of human activity who were sons of ministers. We mention only a few

of these. In science, Agassiz, Fabricius, Jenner, Linnæus, Olbers, Fields, Morse, Berzelius, Euler; in history and philosophy, George John Romannes, John G. Wilkinson, Hallam, Hobbes, Froude, Sloan, Parkman, Bancroft, Schnelling, Schliermacher, Nietzsche, Müller; in art, Reynolds and Christopher Wren; in philanthropy, Clarkson and Granville Sharp, the anti-slavery agitators; in poetry, Lessing, Tennyson, Ben Jonson, Cowper, Goldsmith, Thomson, Coleridge, Addison, Young, John Keble, Matthew Arnold; among essayists, Emerson, Richter, Hazlitt; among novelists, Charles Kingsley, Henry James, and three daughters of clergymen, Jane Austen, Charlotte Brontë, and Harriet Beecher Stowe.

But most remarkable is the long list of celebrated divines who were themselves sons of ministers. Among such are these names, Swedenborg, the seer, Jonathan Edwards, Archibald Hodge, Henry Ward Beecher, Lyman Abbott, Charles Spurgeon, Increase and Cotton Mather, Matthew Henry, the famous commentator, Frederick D. Maurice, Lightfoot, John and Charles Wesley, Mansell, Dorner and Dean Stanley.

In our American history the Field family is a noble example of the influence of clerical households. The father, the Reverend David D. Field was a minister of the Congregational church. One son, David Dudley, was the eminent jurist and law reformer; another, Stephen J., was an associate justice of the Supreme Court; a third son, Henry M., was a useful clergyman and author; and the fourth son was Cyrus W., who laid the Atlantic cable.

It is probable that ministers' sons have exerted more influence in the United States than in any other country. Among teachers, lawyers, doctors, scientists, men of business, and in the church, there are a great host who have been the sons of the manse. Of the more notable men in our history who were sons of ministers we find in political life, Cleveland, Clay, Buchanan, Arthur, Quay, Morton, Beveridge, Hughes, and the lamented Dolliver of Iowa; among jurists, Field and Brewer; among educators, Woodrow Wilson, Faunce, James, Carroll, Lounsbury; in history and literature, Sloan, Parkman, Bancroft, Holmes, Emerson, Henry James, Lowell, Gilder, Van Dyke; in invention and science, Cyrus W. Field, Samuel F. Morse, and Agassiz; in the church, Beecher, Alexander, Hodge, Abbott, Potter, Jonathan Edwards; in philosophy, James. In the Hall of Fame fifty-one famous Americans are honored. Of these fifty-one, ten are the children of ministers: Agassiz, Beecher, Harriet Beecher Stowe, Henry Clay, Jonathan Edwards, Emerson, Lowell, Morse, Bancroft, Holmes.

The Protestant ministry is justified of her children. Like the fabled Pactolus of Syria, whose sands carried the wealth of Crœsus, the ministerial family has flowed down the valleys of our national life weighted with the golden dust of achievement and renown.

HISTORY-MAKING FORCES

By Dr. FRANK T. CARLTON
ALBION COLLEGE

HISTORY is a science; it belongs to the family of social sciences. History is concerned with more than the mere perfunctory cataloging of incidents, with more than a string of events held together by the colorless thread of chronology. It is no longer to be considered a record of sanguinary episodes and of individual prowess or debauchery. True history presents a picture of the struggles of conflicting races, interests, sections and classes; it tells the interesting story of the struggle of the masses upward toward equality. Historical science is a study of cause and effect. In the political and social world, structures are evolved and changes take place in response to modifications in the physical and social environment, or in the industry of the people. Political institutions, wars and royal intrigues are but the visible manifestations of underlying and powerful social, economic, geographic and racial forces. History—true history—is, consequently, a study of the social physics of the past; sociology, of the present. It is, indeed, "the record not of the doings of man, but of his progress." The memoirs of the "not-great" are the most important, but usually the neglected, part of real history. Unless the study of history aids in the solution of the important social and economic problems of to-day, it remains in the lower rank of leisure-class, cultural studies—the value of which is chiefly traditional and putative. In our progressive educational institutions history is not offered merely for the sake of storing up in the mind of the youth a knowledge of the past, for its disciplinary value only, for so-called cultural purposes, or because it is considered to be the proper or conventional kind of knowledge for a college graduate to become familiarly acquainted with.

The medieval mind had no idea of causation in the physical world; only comparatively recently did the men of modern times begin to throw off medievalism in regard to social progress. According to the early metaphysical conception of history, data and investigations were of no value, or of negative value. In a similar way, the medieval authorities considered inductive physical science to be improper and immoral. However, metaphysics and superstition in regard to the evolution of political institutions are fortunately rapidly giving way to scientific hypotheses based upon exact and detailed investigation of historical data.

The proper function of real historical study is to ascertain and ex-

plain in a measure the reason for the rise and fall of specific nations, parties and principles. Before broad and reasonable generalizations can be drawn an enormous mass of exact and uncolored historical data must be gathered and digested. This material must relate not merely to political events or to the work and ideals of certain great and more or less spectacular personages who have stood in the foreground in the generations which lie forever behind the present. This data must, if it be highly valuable, tell the true story of the life, ideals, customs, industrial and social relations of the mass of the common people. Each locality, class and individual can add its quota toward the accurate knowledge of the true history of a given nation.

In the past our historians have often been guilty of presenting a false picture of the history of a nation. Their conclusions have often been very much prejudiced and distorted. In part this unfortunate situation was the direct and inevitable result of a lack of minute and local historical data. In part, it was due to a false idea of patriotism which led the writers to over-emphasize the good qualities of certain historical personages and to accentuate the moral weakness of others; it caused the historians to find altruistic and broad-minded ideals where in reality egoistic and particularistic ambitions were uppermost. Not only were false ideals presented, but the glorification of the past inevitably made the student and reader pessimistic in regard to the present and the future. The past was seen constantly surrounded by an unreal halo. The imaginary good old days and the more or less mythical heroic heros of the past when placed in comparison with the somber, but actual, present checked the enthusiasm of many a young idealist. With this contrast in view the present seemed hopelessly degenerate; corruption, graft and political chicanery were believed to be of recent origin, whereas in reality these evils are as old as history. It is often difficult for the student to realize that the men of former generations were not supermen, but men liable to be influenced by prejudice, partisan bias and ignoble motives. American history has suffered greatly in the past because of superficial and prejudiced interpretation of facts, and because of the lack of definite and accurate data.

The forces concerned in history-making are a multitude in comparison with those more simple and tangible forces which operate in the laboratory of the physicist or the factory of the manufacturer. Each nation and each age has its own peculiar problems, balance of social forces and rate of change. The complexity and the magnitude of the forces involved insure the existence of social inertia. The first law of social change is that social formation and deformation take place gradually. Revolutions, signifying great and abrupt changes in national economic or social life, are more apparent than real. The revolution is a mere surface manifestation. Deep-seated changes never occur in this

way. Forms of government may be radically changed, but the alignment of classes, subordination, legal traditions, religious, ethical and social ideals still remain inevitably to nullify or to modify the results of the newly-made structure of government.

The French Revolution is the classic example of a political revolution. Yet the French Revolution led directly to Napoleon. Absolutism was not immediately abolished by the downfall of Louis XVI. For the stable despotism of the Bourbon ruler was substituted the unstable and constantly changing absolutism of the assembly and the directory and finally of Napoleon. The Reign of Terror was simply the use of direct and primitive methods of maintaining control over the masses and of overriding opposition. Kings, supported by hereditary prestige and crystallized legal and constitutional forms, did not need to use, except occasionally, the crude method of wholesale legal assassination in order to maintain order and subordination. But the newly organized government with its devoted band of untried dictators, unsupported by the trappings and the legal and constitutional mummery, were quickly driven by necessity to the use of the guillotine. An immediate change from absolutism to republicanism was a governmental impossibility. The French Revolution was in effect the spectacular part of a gradual process of social change which greatly modified political conditions in France. A similar conclusion may be drawn from the English revolutions of 1642 and 1688, or from the American revolution.

Nevertheless, governmental structures may retard or modify the course of social change. A written constitution is a crystallization of an outgrown balance of social forces; but it may disturb the balance of forces in the present era. It adds to the strength of one element, and places obstacles in the path of another. Environmental conditions, the mixture of races and nationalities, social customs, tradition, religious ideals and inherited ethical principles may do likewise.

The course of historical events in America furnishes a very interesting and instructive study in social physics. The alignment of social forces in American history presents certain well-marked peculiarities. (1) The importance of the frontier element in our history is perhaps unparalleled. The history of the United States down to recent times has been warped and twisted by the presence of an ever-moving frontier line which has visibly reflected its ideals and views of government back into the legislation and the social composition of the entire country. (2) The absence of a royal or noble class based upon hereditary privilege must not be overlooked. (3) Negro slavery produced dangerous sectional antagonism which led directly to the civil war. The presence of the negro furnishes a very different problem for the American legislator and social scientist of to-day. (4) The continued influx of a large and diverse immigrant class has exercised and is still exercising a

marked influence upon our political and social institutions. Here differences in customs and traditions produce effects similar to those which result from differences in color.

The tradition that woman should remain in the home, that her sphere is the restricted one of the household, is an almost insurmountable obstacle in the path of the woman-suffrage movement. This moss-covered, but orthodox, tradition greatly weakens the effect of the economic forces which are acting to place woman on an economic and political basis level with that occupied by the masculine sex; and thus it retards a development which is indigenous to an industrial community of the occidental type. Human beings are prone to argue on the basis of what has been rather than on the ground of what is. Men hold that good which is customary forgetting that good is always relative to present conditions. Past good is often present evil; and present vices, past virtues.

Laws shortening the working day for men and women, regulating dangerous employments, and permitting the activities of labor unions, are met by an appeal to personal liberty of a kind which is practically meaningless in modern industrial society. Traditional rights are often valueless when studied in the light of the present; but their potency comes from the fact that their appeal is to the emotions, not to the reason, or to class interest rather than to the general welfare or to race improvement. A highly protective tariff is carried down into a time when the primary motive for such regulation is lost, by means of the pressure of certain pecuniary interests built up in a measure by the tariff law itself.

Religious ideals are utilized frequently to retard social change. Religious imperatives and biblical phraseology are invoked to continue the traditional view as to marriage and divorce. The standard of the formalist is that of religious justification or taboo rather than of social welfare; and the particularly unfortunate element in the whole matter is that the average formalist never grasps the idea that his religious imperatives were built up in the past when economic and social conditions were very different from those of to-day. The thoroughgoing formalist is obsessed by the idea of fixity in all moral, ethical and religious ideals and requirements. He is unfortunately so insistent upon upholding a fixed and authoritative ideal of individual goodness or of individual conformity to certain doctrines or ceremonial forms that he can not see the intricacy and complexity of modern social relations and the potency of environmental reaction upon the character and ideals of individual members of society. The religious formalist is a conservative; he is prone to look askance upon the sociologist who is studying the great social cauldron as the chemist examines his test-tube or the biologist the organism under the lens of his microscope. The sociolo-

gist is judged, and rightly judged, to be an innovator and a radical; therefore he is held to be vulgar, uncultured, dangerous, an undesirable individual and probably a "heretic" (whatever that may mean). The religious worker of the future must cast off his antiquated garb and become a student of modern society. If not, his power for good will soon be a vanishing quantity.

One of the most potent conservative and reactionary influences on American progress is our federal constitution. This document was drawn in an era before the trust, the railway, the world market and a multitude of revolutionary discoveries and theories. It can be amended only with extreme difficulty; and has only been continued by stretching the meaning of words to fit new conditions. But as the interpretation of the phraseology of the constitution is given to men who were trained a generation or more ago, and who are members of a profession which is peculiarly precedent-shackled, even this crude method does not suffice to enable our legal forms to conform to the ever-changing social and economic requirements of the present.

As long as free land and a frontier were important factors in the nation, the constitution could be adequately stretched to meet new situations—the old *laissez faire,* individualistic interpretation of liberty and constitutional rights was not seriously out of step with the course of events. But when the frontier disappears, and great industry enters, our legal and constitutional edifice is subjected to serious strain. Liberty, the right of contract, the right to do business, and similar indefinite phrases must be interpreted anew in the light of a changed and complicated economic and industrial situation. Yet, our courts seem prone to decide cases relating to the relation of labor to capital in the same way that John Marshall did. It is apparently forgotten that when aggregated capital faces organized labor, the situation is very different from that which obtained when the isolated employer faced the independent worker. Legal forms have not infrequently concealed and overshadowed common sense and social welfare; the inalienable rights of men often seem to have been displaced by the sacred rights of property and privilege.

Race prejudice often acts as a force opposing economic pressure. Slavery in the south was becoming in 1860 an uneconomical system even for the slave owner; but the progress toward emancipation was blocked by the fear of the free negro and the demand of social conventionalities. The negro race is at the present time handicapped because of race prejudice which prevents its members from obtaining the same economic opportunity as their white-skinned neighbors or competitors. Yet, on the other hand, race prejudice seems frequently, if not usually, to be generated out of economic friction and antagonism, out of the opposition engendered by competition between people accustomed to widely different standards of living.

Education may be an instrument of progress or of conservatism. When emphasis is laid upon the classical or so-called cultural elements, education becomes a potent force in maintaining the *status quo*. When the emphasis is placed upon the narrowly practical—purely trade instruction of a restricted sort—the tendency is to increase the distinction between the different classes in the community. Education only becomes a potent factor in human progress when sociological and psychological principles are introduced to determine the proper treatment of each and every child. The social standard of education is progressive; the business and the cultural standards are conservative or reactionary.

Social scientists are reaching the long-delayed conclusion that happenings in the social and the political sphere are not the result of chance, and individual impulse or willing, or of direct and arbitrary interference of an infinite power. Social and political happenings, like physical and chemical actions and reactions, occur in an orderly and law-abiding manner. Events, movements, reforms, agitations, decay or growth of institutions may, in a measure, be prophesied, directed and aided or retarded. There is, or may be, a social science (or social sciences) as well as physical sciences. Social mechanics, social physics and social chemistry are real terms.

Science is gathering data for cooperative and purposive action. Industrial evolution, city planning, workingmen's insurance, tax reform and socialism are some of the lines along which the infant science of society is slowly feeling its way—like the physical sciences of a few generations ago—in the face of opposition which is often violent, noisy, hypocritical and ignorant. Science has brought order out of chaos and guesswork in the factory. Why can it not do likewise in the nation? To the social scientist rule-of-thumb methods, secrecy, waste of natural and human resources and disregard of social welfare and of race improvement are criminal. The social scientist is becoming an expert, and is acquiring the professional spirit. He is the future maker of history.

INDUSTRIALISM

By Professor CHARLES S. SLICHTER
UNIVERSITY OF WISCONSIN

IT is unusual nowadays to write hopefully of our own times; it is so easy to point out the shortcomings of the industrial age, and so difficult clearly to see beyond the rapid changes of our times and properly to measure the huge forces now at work in society. To many critics, this is but the age of material things; poetry, faith, the hope eternal, have quite forsaken the human heart. Such critics look upon the industrial leader and the engineer as just so much wasted material that might have gone (in a better age, of course) to make a poet or an artist. I shall not attempt to explain industrialism, or to seek an inner meaning without admitting the transient evils—to do so would be to claim that great epochs of readjustment are not periods of discomfort and even disaster to many of the species.

Culture, in its many forms, developed and embraced no new types from the dawn of civilization until modern times, except those which burst forth in the past century. The forces that have brought the race to its present place—at least most of them—are readily agreed upon. First is war, then religion, then poetry and literature, then art, philosophy, commerce, music, capital, politics, society, science, industrialism. The first in this list I name in order of their force or potency. The final two—science, industrialism—I name last with prophetic intent. They are the new giants in modern civilization, and novel in this, that they are the first great forms of culture that are antagonistic to some of the ancient types which have so long dominated human destiny.

Must I justify placing war first among the forces that have given us the civilization of to-day? It is enough to illustrate it by our own century and a third of national experience. War it was that gave us independence. It was the Mexican War that confirmed us a Pacific, as well as an Atlantic, power—with all the consequences that must flow therefrom in the distant future. Again, it was civil war that knit us together as a nation, and made us strong to work out our destiny as a single people. And again it was war that entered us upon our career as a world power, a new nationalism at home, a new imperialism abroad. And lastly, it was war—trivial it is true, only a Panama revolution let loose from Washington, but, nevertheless, war—that gave us Panama and has led to one of the most far-reaching results of all time—namely, the proof that the white man can conquer the tropics. Thus is war the

mightiest, as well as the most monstrous, of the culture forms that have yet influenced the race. No language rolls the "r" sufficiently to pronounce "war" as it should be pronounced.

These old forces of civilization—war, religion, poetry—have been harmonious coworkers; only a few unpleasant incidents to record in the happy family. Whether war for religion's sake, or religion in the cause of war, or poetry in praise of war and its heroes, or poetry in the service of religion, the forces have not often pulled against each other, but, in the main, together, and the paths in the various fields have not been divergent, but convergent. Homer, Achilles, Moses, David, Cæsar, Mohamet, Charlemagne, Dante, Shakespeare are all artists upon the same canvas.

In a large sense, science and industrialism are not two forces, but a single force. Industrialism is merely science in action, or militant science. But in reality this distinction is a large one. To make industrialism from science, one must add other elements—such, for example, as ambition for power, a greed for exploitation, or a lust for money, or any combination of these. Of course industrialism could not have developed except from the soil of science.

The brief history of industrialism is interesting. I shall divide it into three periods. In the beginning the exploitation of labor was, perhaps, the dominant quality. Now the exploitation of labor was nothing new in the world, for it dates back to the time of the first slave. What I mean is that after a long period of partial emancipation in which the common man had gained a certain power of individual assertion and independent existence, industrialism came along and built up the necessary great groups of dependent industrial workers. The exploitation of labor was on a new scale and done almost consciously as in slavery. Then, as industrialism grew and science pointed out more and more what the new movement really meant, the exploitation of labor became more nearly secondary to the exploitation of nature or of natural resources. To take in private possession and hold against the people the natural wealth of a country was, perhaps, not altogether a new thing, but the machines, the processes, the transportation, the organization, the communication that science developed made the exploitation possible and abundantly worth while. Next there entered the third and greatest period, namely, the period characterized by the exploitation of the middle classes. Now here is one of the greatest discoveries of our times. The so-called middle classes are almost solely the product of industrialism. The modern industries of a country and the commerce resulting therefrom are the only forces that have anywhere built up a large middle class. The best ways to tap the savings of this class, although just discovered, are now pretty well worked out. The American industrial trust, the German syndicate, the new-style

organization of banking, the perfected method of handling insurance and trust companies, the public service corporations, the modern stock exchange, are some manifestations of the great vacuum cleaner that is sucking away at the savings of the middle classes. This, I say, is the richest field of exploitation yet discovered. Do not misunderstand me, however. I do not mean that at a meeting of the Directors of the Biggest National Bank, or of the Greatest Life Insurance Company, or of the United States Industrial Corporation, the captain of the captains of industries arises and says: "Gentlemen, the exploitation of the middle classes is the greatest discovery of modern times. What can we do to-day to further this cause? What is next to do to tap the savings of this class?" I say I do not mean that this actually happens. A thing need not be done consciously in order to be done. The result is the same whether done consciously or unconsciously. What I mean is, for example, that a monopoly price for steel against a world market considerably less is an instance of the exploitation of the middle classes. Remember, also, that formerly the savings in the cost of production by improved methods and new inventions largely accrued to the consumer. Under modern organization of industries, this saving goes very largely to increased profits and, more than that, to increased capitalization—that is, from the pockets of the middle classes. Formerly, the leaders in the industries were manufacturers, men not far removed from the middle classes themselves. Now the leaders in the industries are not manufacturers, but so-called financiers, artists in handling funds, men interested in profits, not products—and profits in large part made from the middle class by the nursing of stocks and the shuffling of securities, and not alone by the manufacturing and selling of realities. Again the control of banks and insurance companies, for the purpose of industrial adventure and for strategic ends, works primarily against the middle classes. The irony of the new force, which makes the cleaning-up process almost perfect, is seen in the unloading upon the middle classes themselves, through organized underwriting campaigns and the short circuiting of the market, of the very obligations created in the organization of the exploiting machinery.

There are many other counts that might be added to the true bill against industrialism. Many of these are often brought to our attention by those who dote on the apparent shortcomings of the present era. Industrialism has augmented and aggravated city life, and has put the moral and physical fibers of men to new tests. It has attracted the brightest intellects to leadership in its army, much to the loss of politics, and the professions and the arts. All these things are, in a way, true. But it is not the purpose of this paper to convict industrialism, but to acquit it, so I must not catalogue its apparent shortcomings. I shall now attempt to show that industrialism, moving forward on the

rails laid by science, is working for good and not for evil, and that the things commonly criticized are but transient phases of a great movement, which, in its main features, is making for the advance of the race and toward the very highest ideals.

Let me again remind you that industrialism is but another name for science in action. The pure science of the study or laboratory it is not. This same science joined to some form of worldly ambition is industrialism. Therefore, where science leads, it must follow. It is, I claim, the most dependent upon science of all purely worldly activities. These things I shall attempt to make clear as I proceed. Trace forward what science must do for us, and we shall comprehend whither industrialism is leading .

Do not forget these truths: It is science that is dominating this age, this twentieth century, and not industrialism. Science works through industrialism. Science dominates industrialism. Science corrects the evils it itself creates. Science has not only changed the forms and conditions of our physical existence, it has altered our mental life, has controlled our views and changed the basis upon which rest our fears, hopes and opinions. The old forms of culture have been so long present as factors in the life of the race, that it is hopeless to trace out their due contribution to society. Causes have slowly fused with effects, and influences, at first external, have become internal, a part of life itself. Not so with the newest type of culture. Science is now at work remaking the world, primarily a force from without. Its first great effect is spiritual rather than material. It has spread through humanity a spirit of optimism. It has made optimists of every one, especially of the common man. So much has been accomplished by science, although but vaguely comprehended, that the ordinary man deems all things possible. Science, through its many phases and effects, has become the moral sunshine of modern life. It warms and cheers and gives a joy and hope to this present life that former generations but hesitatingly attributed to a future existence.

I shall now illustrate the way in which science corrects the evils it itself creates, and show that the dangers brought in by the new culture are merely transient. Science, the father of industrialism, is the ultimate parent of that tremendous exploitation of the natural wealth of the world which in two generations has spent more of our coal, iron and many other resources than were used by all of the preceding generations. Science has created the problem of conservation. Now I read nowhere in the books of the conservationists that science is the real criminal that has caused our natural resources to be exploited. Perhaps I find it not there, because science, now the prosecutor, must forget its own crimes.

Science has not only created the problem of conservation, but it has spread abroad a spirit of optimism that makes men believe that all will

still be well when the soil is in the ocean, and iron is rust and the last lump of coal is on the hearth. It is science that has created the new faith that makes of conservation a real and a difficult problem. But if science has created the problem of conservation and has spread a faith as an obstacle to its solution, it is still true that science alone can furnish the remedy. It is but poetic justice that science and the leaders in science must now point the way and carry much of the burden. Science must now give, and it is giving, the solution of the problem it itself has created.

What is true of the problem of conservatism is true of all of the difficulties and evils brought to us by science, whether directly or through industrialism. Science brings its own remedies and removes the evils it itself creates. If it were otherwise, science would not be science.

A second influence of industrialism that is rarely credited to it is the changed view held by the prosperous classes as to their obligation to society in general. Public opinion no longer supports the man whose life brings no form of high service to his fellow men. The very fact that business and industry are organized on so large a scale soon convinces us that the personal independence of the proprietor no longer exists. Scores of new dependencies and checks hem him about. He sees that his life must be one of social purpose and not pleasure. As obscurely as this truth is often seen, and as glaringly as it is contradicted by the sporty spirit and the society itchings of the new-rich, we must hold it as one of the characteristics of our era that social purpose and not play is dignified by industrialism. Riding to hounds as a vocation no longer gives the complete social satisfaction that it once did.

Let us now turn from these, which are, after all, minor influences of industrialism, to a consideration of some of the major tendencies. Perhaps the greatest mission of science and industrialism to our era is the removal of controversy from human progress. This is indeed a great service to mankind—to narrow the field of strife, to remove obstacles, to settle great public matters by bringing to bear accurate data, adequate analysis of cause and effect, and expert judgment—so that contention, or partisanship or politics, is eliminated, and things are settled on their merits. This phase of the industrial age is fast developing. The numerous expert commissions appointed by the states and government to investigate and determine important questions upon the basis of exact knowledge is a pertinent illustration. The Wisconsin Commission is settling all matters concerning the public utilities solely after adequate investigation and skilled tests. These same matters can never again become the football of partisanship or political manipulation. Likewise the commission form of municipal government is removing from the field of politics, and local contention, questions which are really largely

matters of skill and exact science. The best kind of water supply, the proper sort of sewage disposal, the best way to handle streets, street-railways, public parks, schools, playgrounds, public health, the housing problem, etc., are no longer matters of fight or ballot in well-ordered communities. There exists always a best way and experts are selected to find and direct it. The modern civilized community is no longer a state, but a school. The body politic has become one vast, complexly organized, research institution. Governments are, in this age of industrialism, instruments for replacing darkness with light, for substituting for the indefinite and approximate, the definite and accurate. This is about all there is to the best public service. The state has become a great thinking, investigating organization, or laboratory, or research institution. There is this distinction between the school and the state: the school researches only, the state researches and acts.

The illumination of great public matters by modern scholarship is best illustrated by what is constantly occurring in the countries of western Europe. There, as every one knows, municipalities are in the hands of experts whose life work is a study, as in a laboratory, of the needs of the community and its individuals. Nothing is left to chance, and little to choice, except when the people can be trusted to choose wisely. The city and state with its utilities, sanitary inspection, land purchase, construction and sale of homes for working men, control of food, care of children, supply of milk, expert advice to mothers, the promotion of all sorts of special schools, museums, galleries, theaters, concert halls, municipal banks, pawnshops, employment bureaus, industrial insurance, old-age pensions, etc., etc., is conducting a laboratory for racial and civic betterment, and is carrying upon the broad shoulders of the state the burden that a democracy would shift to the people themselves. All new or difficult questions receive special study and an honest attempt is made to settle them in the best manner.

The doctrine of the president of the University of Wisconsin that the state university exists for and should serve all of the people of the state is but a recognition in another form of a principle which has been admitted by older civilizations for a generation or more. Whether an American state will be willing to go at present very far on this path is questionable. It is too far a step from the reign of pull and graft to the rule of knowledge. But in the end the state will accept the higher leadership, no matter how many ups and downs may intervene.

Another of the major influences of industrialism has been its destructive power over democratic government. Democracy, the dream of the eighteenth century, became the illusion of the nineteenth. Government of the people, by the people, has not only never been realized, it would probably have been undesirable, if realizable. Whatever name may be given to the modern well-ordered government, it is not democ-

racy. The duties of the state have become too complicated, too much continuity of service and scholarship is required of its experts, to permit that direct dependency upon the electors that democracy presupposes. About as well select a university faculty by popular vote, as to get together the administrative body of a great state by choice of the people. Those governments which are most democratic in form have not always been most democratic in fact. In America we have had rule by those who could profit most by ruling. Again, American democracy has been minimized by the courts of law, a new sort of autocracy but little dreamed of by the makers of our government—a form of autocracy that would long ago have proved intolerable were it not for the scholarship and patriotism of our higher courts. The popular preachers of democracy, such as Roosevelt and La Follette, contradict their own doctrine of the cure of democracy by more democracy, by many of the policies they advocate. The short ballot, the numerous commissions and many other planks of their platform have little to do with government of the people, by the people. What is left is government for the people. There is daily less and less in government that can be left to chance and less that should be left to choice. The public welfare has become complex, controlled by the intricate forms of modern organized society. Its proper guidance is a subject of skill and knowledge and special training, rather than a matter of votes.

The last of the major influences of industrialism that I shall consider is the effect upon Christianity. A startling phenomenon of the nineteenth century was the panicky alarm shown for a time by the church as science rather suddenly took its place among the older forces of civilization. The churchmen became especially agitated at Darwinism and the laying bare of the facts at the basis of the genesis of species. The good Bishop of Oxford, in his now famous attack on Darwinism at the British Association meeting of 1860, was as little prepared for the celerity with which his position would become obsolete among his own clergy as he was unready for the swiftness and completeness of Huxley's reply. For a time there was conflict and controversy. Then there followed peace. The clergy soon realized that to be priests of darkness was not to be priests at all. The church discovered that there could be no enemy in science and scholarship. Even to the present time, however, the world has not fully awakened to the fact that science is not only not an enemy, but that it is the most potent ally that Christianity has yet found. During the twenty centuries of its history Christianity has not struggled alone. War, poetry, art, music, have diligently served it. But it has required the slow treading of centuries to find that war has no place in such a list. It seems unbelievable, sometimes, that the progress of great ideas should be so incredibly slow among our race. The patience of Providence is boundless, for al-

most without exception, his great truths penetrate humanity only after many centuries. Christianity itself is no exception. In one sense, Christianity may be said to have died out a generation or two after the death of Christ, for its fundamental truth then began to vanish. When in the middle ages the church deemed itself more powerful than worldly dynasties, it had, in the essence of Christ's teachings, lost all but the semblance of the truth. Christianity was too profound a doctrine and humanity too frail a vessel.

The essential and profound truth of Christianity I take to be this: that the law of the jungle, the law of the tooth and claw, must be replaced for the human species by a higher law; that humanity can only reach its most perfect development and realize the highest ideals through the reign of unselfishness. The beginning of Christianity thus marks the transition of man from the kingdom of a lower to the kingdom of a higher being. The Golden Rule is the definition that discriminates one domain from the other. It has become the mission of the industrial age to separate out from Christianity the essential from its unessential doctrine.

That the message of Christ is opposed to some of the primitive forces of culture, such as war, for example, has been but poorly discerned. War is the most perfect embodiment of human selfishness. It is selfishness in its most concentrated and brutal form. Let us give credit to this industrial age that has laid bare these simple truths. Science has replaced war in the list of the allies of Christianity. The exploration of nature has revealed and demonstrated the inadequacy of the law of the jungle for human progress. Science has supplied us with the methods and the laws wherewith to check up human phenomena and to show wherein and to what extent the selfish elements are controlling in human activities. Science is supplying the instruments, the test tubes and the balances, not for material things alone, but for checking up our own experiences, and for applying to life itself those tests that determine the elements that control in each configuration.

If science has given us the tools, the methods, the point of view, industrialism has given us the laboratory and the fiery furnace in which to test them. The bringing of men together in great dependent groups, the subdivision of human effort, the new conditions of life, the accidents and dangers of modern industrial employment, have forced upon us problems in bulk, and not in single instances. The business world has shown how to divide up investments, risks and profits by the joint stock organization. It has drilled us in the elimination of hazards and the division among the many of the ownership and reward of the industries. This very phenomenon emphasizes by contrast and makes inevitable the consideration of the sharing of the hazards of the life of the individual by society in general. To place the burdens of the individual upon the

broad shoulders of the state is therefore but a reflex from industrialism itself. A community of interests among the prosperous classes and class hatred between the proprietary and the working classes can not permanently coexist. If the industrial trust brings peace where there was war, this peace must finally extend to humanity itself. Industrialism has eliminated the middle ground and the possibility of compromise. Peace between the giant groups is progress—warfare between the giant groups is destruction. Science cures the ills it itself creates.

There is thus brought up to our era as the essential terms of permanence, the acceptance of the fundamental message of Christianity. Unselfish cooperation, appreciation and love of our fellow travelers, is the condition of progress. The industrial age, as it develops, must become the most cultured, the most gracious, the kindliest of the eras that the human family has yet lived. Industrialism compels the rule of men by the principle of charity. It has brought us to a climax in human affairs. Society can push forward only on the basis of a revived and reconstructed Christianity. Charity, love, unselfishness, the Golden Rule—whatever you may name the law—has begun to be the necessary and sufficient condition of advance. This present era is not the old age of Christianity—it is its childhood. As the biologist might say, the Industrial Age is a period of rapid mutation. The type is changing. It is a day of hope and of optimism, such as the world has not hitherto known.

THE INHERITANCE OF FECUNDITY[1]

By Dr. RAYMOND PEARL
MAINE AGRICULTURAL EXPERIMENT STATION

A THOROUGH and searching investigation of two great biological problems is a necessary prerequisite to any substantial advance of the science of eugenics. These problems are:

1. The mode of inheritance of human characters and traits of all kinds.

2. The physiology of reproduction in man, particularly with reference to human fecundity and fertility.

The progressive decline of the birth-rate in all, or nearly all, civilized countries is an obvious and impressive fact. Equally obvious and much more disturbing is the fact that this decline is differential. Generally it is true that those racial stocks which by common agreement are of high, if not the highest value, to the state or nation, are precisely the ones where the decline in reproduction rate has been most marked.

The causes concerned in the production of these results are without question exceedingly complex and difficult, if not impossible, of complete analysis. But of one thing we may be certain; somewhere in the complex of causes is included the biological factor as one element. Fecundity and fertility are physiological characters of the organism, subject to variation and capable of being inherited, just in the same manner as structural characters. We must be in possession of definite information regarding the physiology of fecundity and fertility, before it will be possible to make safe and sure advance in the social and eugenic analysis of matters involving these factors, such as, for example, the declining birth-rate.

The basic eugenic significance of that characteristic of organisms termed fecundity furnishes sufficient justification, I hope, for bringing to the attention of this Congress certain results regarding fecundity in one of the lower animals, namely the domestic fowl. In some particulars the results are, I believe, novel. They indicate, for the first time, the precise mode by which this complex physiological character fecundity is inherited. It will be the purpose of this paper to present—necessarily very briefly and without the detailed supporting evidence—the essential results of a study of fecundity in poultry, pointing out at the end some possible eugenic bearings of the results.[2]

[1] This paper was read at the First International Eugenics Congress, held in London, July 24–30, 1912.

[2] The results set forth below were first presented at the meeting of the American Society of Naturalists at Princeton, N. J., in December, 1911. A

During the course of this investigation into the inheritance of fecundity in the domestic fowl, which has now involved thirteen generations and several thousand individuals, two definite and clear-cut results have come to light. These are:

First: that the record of egg production or fecundity of a hen is not, of itself, a criterion of any value whatsoever from which to predict the probable egg production of her female progeny. An analysis of the records of production of large numbers of birds shows beyond any possibility of doubt that, in general, there is no correlation between the egg production of individuals and either their ancestors or their progeny.

Second: that, notwithstanding the fact just mentioned, fecundity is, in some manner or other, inherited in the domestic fowl. This must clearly be so, to mention but a single reason, because it has been possible to isolate and propagate from a mixed flock "pedigree lines" or strains of birds which breed true, generation after generation, to definite degrees of fecundity. Some of these lines breed true to a high condition or degree of the character fecundity; others to a low state or degree.

Definite as these results are, they give no clue as to *how* fecundity is inherited; what the mechanism is. It is believed that now a first approximation to the solution of this problem has finally been reached. While there remain obscure points yet to be cleared up, and more data are needed definitely to decide between certain alternatives, yet the results now in hand appear to indicate quite clearly the general character of the mechanism of the inheritance of fecundity, and to show what lines further investigation of the problem may most profitably take.

At the outstart it will be well to understand clearly what is meant by the term fecundity as here used. I have used the term "fecundity" only to designate the innate potential reproductive capacity of the individual organism, as denoted by its ability to form and separate from the body mature germ cells. Fecundity in the female will depend upon the production of ova and in the male upon the production of spermatozoa.

Fecundity is obviously a character depending upon the interaction of several factors. In the first place the number of ova separated from the body by a hen or any other animal must depend, in part at least, upon an *anatomical* basis, namely the number of ova present in the ovary and available for discharge. Further there must be involved a series of physiological factors. It has been possible to prove that the mere presence of an anatomically normal reproductive system, including a normal ovary with a full complement of ova, and a normal ovi-

complete report with full presentation of the experimental data will shortly be published in the *Journal of Experimental Zoology.*

duct, is not enough to insure that a hen shall lay eggs, that is, exhibit actual as well as potential fecundity. While comparatively very rare, cases do occur in which a bird possesses a perfect ovary and perfect oviduct and is in all other respects entirely normal and healthy, yet never lays even a single egg in her life time. Such cases as these prove: first, that what we may call the anatomical factor is not alone sufficient to make potential fecundity actual; and second, that the anatomical and physiological factors are distinct, in the sense that the normal existence of one in an individual does not necessarily imply the coexistence of the other in the same individual.

Turning now to the physiological factors involved in fecundity, it would appear that there are at least two such factors or groups of factors. The first of the physiological factors involved may be designated the "normal ovulation" factor. By this is meant the complex of physiological conditions which, taken together, determine the laying of about such a number of eggs as represents the normal reproductive activity of the wild *Gallus bankiva*. It must be remembered that, for reasons which can not be gone into here, under conditions of domestication the activity of this normal ovulation factor will mean the production of considerably more eggs than under wild conditions. Egg production involves certain definite and rather severe metabolic demands, which under wild conditions will not always, or even often be met. Further, as has been especially emphasized by Herrick, egg-laying in wild birds is simply one phase of a cyclical process. If the cycle is not disturbed in any way the egg production is simply the minimum required for the perpetuation of the race. If, however, the cycle is disturbed, as, for example, by the eggs being removed from the nest as fast as they are laid, a very considerable increase in the total number of eggs produced will result.

It is a fact well known to poultrymen, and one capable of easy observation and confirmation, that different *breeds* and *strains* of poultry differ widely in their laying capacity. In saying this the writer would not be understood to affirm that a definite degree of fecundity is a fixed and *unalterable* characteristic by any particular breed. The history of breeds shows very clearly that certain breeds now notably poor in laying qualities were once particularly good. One of the best examples of this is the Polish fowl. But, in spite of this, not only do these breed and strain differences in fecundity exist, and probably always have existed, but they are *inherited*. Such inherited differences are independent of feeding or any other environmental factors. Thus a strain of Cornish Indian Games with which I have worked are poor layers, regardless of how they are fed and handled. This is merely a statement of particular fact; it does not imply that there may not exist other strains of Cornish Indian Games that are good layers.

Now in individuals which are high layers, and have this characteristic in hereditary form, there must be involved some sort of physiological factor in addition to the normal ovulation factor already discussed. An analysis of extensive statistics has shown that high fecundity represents essentially an addition of two definite seasonal, laying cycles to the basis normal reproduction cycles. These added periods of productivity are what may be called the winter cycle and the summer cycle. The winter cycle is the more important of these. It is the best measure of relative fecundity which we have and has been used as the chief unit of fecundity in these studies. It constitutes a distinct and definite entity in fecundity curves. The existence of these added fecundity cycles in high laying birds must depend upon some additional physiological factor of mechanism besides that which suffices for the normal reproductive egg production. Given the *basic* anatomical and physiological factors, the bird only lays a *large* number of eggs if an additional factor is present.

We may next consider in greater detail these factors influencing fecundity, taking first

The Anatomical Basis of Fecundity

Since, as already pointed out, egg production obviously depends in part upon the presence of ova in a normal ovary, a question which demands consideration is the following:

To what extent are observed *variations* in fecundity (*i. e.*, in the number of eggs laid) to be referred to anatomical differences? In other words, does the ovary of a high-producing hen with, for example, a winter record of from 75 to 115 eggs contain a larger number of oocytes than does the ovary of a hen which is a poor producer, laying *no* eggs in the winter period and perhaps but 10 or 15 eggs in the year?

To get light upon this question the observations to be described have been made. The object was to arrive at as accurate a relative judgment as possible regarding the number of oocytes in the ovaries of different individual birds. It is, of course, impossible practically to determine accurately the total absolute number of oocytes in the ovary. What can be done, however, is to count the number of oocytes which are visible to the unaided eye. While such results do not tell us, nor enable us to estimate with great accuracy, the total number of oocytes in the ovary, they do, nevertheless, throw interesting and useful light on the questions raised above. Some counts of this kind are shown in Table I.

From this table it is in the first place clear that the number of oocytes in the ovary of a hen is very large; much larger, I think, than has generally been supposed. While, to be sure, there are for the most part only vague statements respecting this point in the literature,

usually these statements are to the effect that the bird's ovary contains "several hundred" ova.

TABLE I

Showing the Number of Visible Oocytes in the Ovary of Certain Fowls

Case No.	Bird No.	Breed	Winter Production	Total Visible Oocytes
1	8,021	Barred Plymouth Rock	3	1,228
2	8,017	Barred Plymouth Rock	0	1,666
3	8,030	Barred Plymouth Rock	0	914
4	8,005	Barred Plymouth Rock	5	1,174
5	1,376	Barred Plymouth Rock	3	2,306
6	8,018	Barred Plymouth Rock	0	1,194
7	8,009	Barred Plymouth Rock	0	2,101
8	8,010	Barred Plymouth Rock	5	1,576
9	425	Barred Plymouth Rock	0	1,521
10	3,546	White Leghorn	54	2,452
11	2,067	White Leghorn	32	3,605
12	3,453	White Leghorn	0	1,701
13	3,833	White Leghorn	0	2,145
14	52	Cornish Indian Game	13	1,550
15	71	F_1 Cross	106	2,000

Not only is the absolute number of oocytes large, but it is also very much larger than the number of eggs which any hen ever lays. A record of 200 eggs in the year is a high record of fecundity for the domestic fowl, though in exceptional cases it may go even a hundred eggs higher than this. But even a 200-egg record is only a little more than a *tenth* of the average total number of *visible* oocytes in a bird's ovary, to say nothing of the probably much larger number of oocytes invisible to the unaided eye, but capable of growth and development. In other words, it is quite evident from these figures that the potential "anatomical" fecundity is very much higher than the actually realized fecundity. This is true even if we suppose the bird to be allowed to live until it dies a natural death.

An examination of the table in detail indicates that there is no very close or definite relationship between the number of visible oocytes on the ovary and the winter production of a bird. Thus No. 1,367 and No. 3,546 each have about the same number of visible oocytes, yet one has a winter production record 18 times as great as the other. Again No. 71 with the extraordinarily high winter record of 106 eggs has only a little more than one half as many visible oocytes as hen No. 2,067, whose winter production record is only 32 eggs. Again, No. 71 with its 106 record has very nearly the same oocyte count as No. 8,010 with a winter record of zero. In general it may be said that the present figures give no indication that there is any correlation between fecundity as measured by winter production, and the number of oocytes in the ovary. Of course, the present statistics are meager. More ample figures are needed (and are being collected) from which to measure the correlation between actual and "anatomical" fecundity.

The data now in hand, however, indicate clearly, it seems to me, that there must be some other factor than the anatomical one involved in the existence of different degrees of actual fecundity in the domestic fowl. It evidently is the case that when one bird has a winter record of twice what another bird has it is *not* because the first has twice as many oocytes in the ovary. On the contrary, it appears that *all* birds have an anatomical endowment entirely sufficient for a very high degree of fecundity, and in point of fact quite equal to that possessed by birds which actually accomplish a high degree of fecundity. Whether or not such high fecundity is actually realized evidently depends then upon the influence of additional factors beyond the anatomical basis. As has already been indicated in the preceding section, it is reasonable to suppose that these factors are physiological in nature.

The Mechanism of the Inheritance of Fecundity as Measured by Winter Egg Production

A study of numerous statistics shows that hens fall into three well defined classes in respect to winter production. These classes include (*a*) those birds which lay no eggs whatever in the winter period (up to March of the laying year); (*b*) those that lay but have a production during the period of something under about 30 eggs; and finally (*c*) those whose production exceeds 30 eggs in the winter period. The division point between the two latter classes is not sharply defined in every case, but it is plainly at about 30 eggs in the case of the breeds and strains used in these experiments. Since in the analysis some fixed point must be taken for this boundary, a production of 30 has been chosen for this purpose and will be used throughout. This is an arbitrary choice only in the sense that it is a convenient round number lying very near where the biological division point falls, at least in the strains of domestic fowls used in these experiments. The analysis could doubtless be carried through nearly or quite as well by taking the division point at a production of 29 or 31, but 30 is a more convenient figure.

In making the division of winter egg production into three groups it must be remembered that this is a character subject to purely somatic fluctuations and environmental influence. Allowance for these factors must be made in interpreting and classifying results.

Turning now to the symbolic analysis, we have to deal with three factors. These are:

1. An anatomical factor. This is basic. It consists in the presence of a normal ovary, the primary organ of the female sex. In the genetic analysis a separate letter need not be used for the designation of this factor, but instead it will be understood to be included in the letter denoting the presence of the female sex or its determiner. That is, *F*

will denote the presence of the ovary or the ♀ sex determiner. Then f will denote the absence of femaleness and the absence of an ovary. Obviously a separate letter is not needed for this "anatomical factor," since the presence of an ovary is the objective criterion of the existence of the female sex, its absence of the existence of the male sex.

2. The "first production" factor. This is the primary physiological factor which in coexistence with F makes the bird lay eggs during the winter period. Quantitatively it may be taken as determining a winter production of more than zero eggs and less than 30. The presence of this factor will be denoted by L_1.

3. The "second production" factor. This is a second physiological factor, which in coexistence with F and L_1 leads to *high* fecundity. The presence of this factor will be denoted by L_2 and its absence by the corresponding small letter. When F and L_1 are present the addition of L_2 makes a winter production of over 30 eggs. If F is present and L_1 absent the presence of L_2 leads to a winter production of under 30 eggs. Thus either L_1 or L_2 alone makes a record of 30 eggs. They are independent determiners of this degree of production. It should be pointed out, however, that in spite of their equivalence in this regard the factors L_1 and L_2 are not qualitatively the same. That is, the increased production when L_1 and L_2 are both present is not because there are present two "doses" of the same determiner. The proof of this is found in the fact that when there are two "doses" of L_1 present in a bird it does *not* make her a high producer. L_2 may be considered an excess production factor, which erects a superstructure on the foundation furnished by L_1. In the absence of L_1 it lacks the foundation from which to start, and hence only can build about as high as L_1 would alone. Of course, it will be understood that in the presence of f (absence of female sex and ovary) these physiological fecundity factors L_1 and L_2 are simply latent.

Using the letters in the manner defined above, and with the usual Mendelian method of writing gametic and zygotic formulæ, the data indicate that there exist 9 different types (in respect to fecundity) of Barred Plymouth Rock males, 6 types of Barred Plymouth Rock females, 3 types of Cornish Indian Game males, and 3 types of Cornish Indian Game females. The only point needing particular attention in reference to these formulæ is that the factor L_2, the excess production factor, behaves in inheritance as a *sex-limited* or *sex-correlated character*. It is repelled by the female determiner F. It is thus like the barred pattern factor in the Barred Plymouth Rock fowl.[3] In consequence gametes of the type FL_2 are never formed. *Any gamete which bears F does not, under any circumstance, ever carry* L_2. All females

[3] Cf. Pearl, R., and Surface, F. M., *Arch. f. Entwick. Mech.*, Bd. XXX., pp. 45–61, 1910, and *Science*, N. S., Vol. XXXII., pp. 870–874, 1910.

which carry the excess production factor L_2 are heterozygous in respect to it.

We have fecundity practically determined, then, by two physiological factors, one of which is sex-correlated in its inheritance and the other not.

TABLE II

Showing Some Results of Mating Together Barred Plymouth Rock Males and Barred Plymouth Rock Females of Different Fecundity Genotypes. Summarized Data

Matings	Distribution of Daughters in Respect to Winter Egg Production			
	Class	Over 30 Eggs	Under 30 Eggs	Zero Eggs
♂ $fL_1L_2 \cdot fl_1l_2$ × ♀ $fL_1L_2 \cdot Fl_1l_2$ (high producer).	Observed	21	30	8
	Expected	22.1	29.5	7.4
Average winter egg production in each class.		48.85	16.34	0
♂ $fL_1L_2 \cdot fl_1l_2$ × ♀ $fL_1L_2 \cdot FL_1l_2$ (high producer).	Observed	21.5[1]	16.5	0
	Expected	19	19	0
Average winter egg production in each class.		50.38	16.69	—
♂ $fL_1L_2 \cdot fl_1l_2$ × ♀ ♀ of all types taken together.	Observed	51.5	62.5	11
	Expected	51.45	62.5	11.05
Average winter egg production in each class.		47.94	15.34	0
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ $fL_1L_2 \cdot Fl_1l_2$ (high producer).	Observed	92.5	103.5	7
	Expected	101.5	101.5	0
Average winter egg production in each class.		54.19	15.52	0
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ $fL_1L_2 \cdot FL_1l_2$ (high producer).	Observed	111	6	0
	Expected	117	0	0
Average winter egg production in each class.		56.47	20.33	—
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ $fL_1l_2 \cdot Fl_1l_2$ (low producer).	Observed	29	23	2
	Expected	27	27	0
Average winter production in each class.		47.93	15.30	0
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ ♀ of all types taken together.	Observed	243	149	10
	Expected	255.5	146.5	0
Average winter egg production in each class.		53.67	15.37	0
♂ $fL_1L_2 \cdot fl_1L_2$ × ♀ $fL_1L_2 \cdot Fl_1l_2$ (high producer).	Observed	20	6	3
	Expected	21.75	7.25	0
Average winter production in each class.		56.90	24.17	0
♂ $fL_1L_2 \cdot fL_1l_2$ × ♀ ♀ of all types taken together.	Observed	19	16	0
	Expected	17.5	17.5	0
Average winter egg production in each class.		55.47	18.3	—
♂ $fl_1L_2 \cdot fl_1l_2$ × ♀ ♀ of all types taken together.	Observed	8.5	15.5	5
	Expected	10.25	14.5	4.25
Average winter egg production in each class.		60.50	12.26	0

The accordance between observed fact and theoretical expectation on this interpretation of the results is shown in the following tables

[1] The records of ½ refer to birds whose winter production record was exactly 30 eggs. Each one of the few birds of this sort is divided between the "Over 30" and the "Under 30" classes.

which give the results of a portion of the actual experiments. As the experiments were rather extensive, it is not possible here to present anything like the complete material. Only representative matings are here given. Table II. gives the results of some of the B. P. R. × B. P. R. matings in detail, in order to show, not only the accordance between observation and theory, but also the distinctness of the classes of fecundity segregated (shown by the *average* winter production in each segregated class).

From the data set forth in the above table there can be no doubt as to the fact of the Mendelian segregation of fecundity, nor as to the entire distinctness of the things segregated.

In order to give a general survey of the results, and to demonstrate the reality of segregation over the wide range of material included in the experiments, the summary Table III is presented.

TABLE III

Showing the Observed and Expected Distribution in Respect of Fecundity of the Adult Female Offspring from all Matings in each of the Classes Tested in the Experiments

Matings	Winter Production of Daughters			
	Class	Over 30	Under 30	Zero
All Barred Plymouth Rock × Barred Plymouth Rock.	Observed	365.5	259.5	31
	Expected	381.45	257.25	17.30
All Cornish Indian Game × Indian Game.	Observed	2	23	15
	Expected	0	25	15
All F_1 (B.P.R. × C.I.G. and reciprocal cross).	Observed	36	79	8
	Expected	26.5	86.75	9.75
All F_2 (F_1 × F_1, and F_1 × parent forms in all possible combinations).	Observed	57.5	98.5	23
	Expected	68.60	95.00	15.40

Considering the nature of the material and the character dealt with the agreement shown between observation and hypothesis is certainly as close as could reasonably be expected. Such discrepancies as are shown in the above table are fully discussed and their probable physiological explanations set forth in detail in the complete account of these experiments.

The detailed data given in the complete paper, of which the above discussion and tables *give merely a very incomplete abstract,* appear definitely to establish the following points:

1. That fecundity in the domestic fowl is inherited strictly in accordance with Mendelian principles.

2. That observed individual variations in fecundity here depend upon two separately inherited physiological factors, L_1 and L_2.

3. That *high* fecundity is manifested only when both of these factors are present together in the same individual.

4. That either of these factors when present alone whether in homo-

zygous or heterozygous form causes about the same degree of *low* fecundity to be manifested.

5. That one of these factors, namely L_2, is sex-limited or sex-correlated in its inheritance, in such way that in gametogenesis any gamete which bears the female sex determinant F does not bear L_2.

6. That there is a definite and clear-cut segregation of high fecundity from low fecundity, in the manner set forth above.

These conclusions are fully and independently substantiated by long-continued breeding experiments involving the breeding together of (1) Barred Plymouth Rock males and females (a breed of generally high fecundity), (2) Cornish Indian Game males and females (a breed of generally low fecundity, (3) the F_1 and F_2 offspring from reciprocal crosses of Barred Plymouth Rocks and Cornish Indian Games and all possible matings *inter se* and with the parent forms of the cross-bred F_1 and F_2 offspring.

While these results may have no direct eugenic bearing, they do, I believe, have an important indirect connection with eugenic problems. In the first place, these results furnish a novel conception of the mode of inheritance of fecundity. They show that this highly variable physiological character is inherited in accord with simple Mendelian principles. They further show that simple selection of highly fecund females alone is not sufficient to ensure high fecundity in the race.

From the eugenic standpoint they suggest, though of course they do not prove, that possibly some part of the observed decline in human fecundity in highly civilized races may be due to the dropping out or loss of one or more of the genes upon which high fecundity depends, this loss being coincident with the complete cessation of the natural selection of highly fecund types.

Finally, these results on fecundity in fowls not only emphasize the importance of analytical studies to determine the precise mode of inheritance of human fecundity, but they also furnish a guide and stimulus for the conduct of such studies. If, as in the actual fact, it can be shown that in one animal belonging to the same great phylum to which man himself belongs (the vertebrate) fecundity is inherited in a simple Mendelian fashion, it encourages one to hope that some time a solution of the same problem may be reached for man. It at least points the way to a mode of attacking this complex problem which gives greater promise of leading ultimately to a solution than does any method which has hitherto been applied to it.

STUFFY ROOMS[1]

By LEONARD HILL, M.B., F.R.S.

LAST year the distinguished president of this section raised us to the contemplation of the workings of the soul. I ask you to accompany me in the consideration of nothing higher than a stuffy room. Every one thinks that he suffers in an ill-ventilated room owing to some change in the chemical quality of the air, be it want of oxygen, or excess of carbon dioxide, the addition of some exhaled organic poison, or the destruction of some subtle property by passage of the air over steam-coils, or other heating or conducting apparatus. We hear of "devitalized" or "dead" air, and of "tinned" or "potted" air of the battleship. The good effects of open-air treatment, sea and mountain air, are no less generally ascribed to the chemical purity of the air. In reality the health-giving properties are those of temperature, light, movement and relative moisture of the surrounding atmosphere, and leaving on one side those gross chemical impurities which arise in mines and in some manufacturing processes, and the question of bacterial infection, the alterations in chemical composition of the air in buildings where people crowd together and suffer from the effects of ill-ventilation have nothing to do with the causation of these effects.

Satisfied with the maintenance of a specious standard of chemical purity, the public has acquiesced in the elevation of sky-scrapers and the sinking of cavernous places of business. Many have thus become cave-dwellers, confined for most of their waking and sleeping hours in windless places, artificially lit, monotonously warmed. The sun is cut off by the shadow of tall buildings and by smoke—the sun, the energizer of the world, the giver of all things which bring joy to the heart of man, the fitting object of worship of our forefathers. The ventilating and heating engineer hitherto has followed a great illusion in thinking that the main objects to be attained in our dwellings and places of business are chemical purity of the air and a uniform draughtless summer temperature.

Life is the reaction of the living substance to the ceaseless play of the environment. Biotic energy arises from the transformation of those other forms of energy—heat, light, sound, etc.—which beat upon the transformer—the living substance (B. Moore). Thus, when all

[1] Address of the president to the Physiological Section of the British Association for the Advancement of Science, Dundee, 1912.

the avenues of sense are closed, the central nervous system is no longer aroused and consciousness lapses. Laura Bridgeman, paralyzed in almost all her avenues of sense, fell asleep whenever her remaining eye was closed. The patient who lost one labyrinth by disease and, to escape unendurable vertigo, had the other removed by operation, was quite unable to guide his movements or realize his position in the dark. Rising from bed one night, he collapsed on the floor and remained there helpless till succor arrived.

A sense organ is not stimulated unless there is a change of rate in the transference of energy; and this to be effectual must occur in most cases with considerable quickness. If a weak agent is to stimulate, its application must be abrupt (Sherrington). Thus the slow changes of barometric pressure on the body surface originate no skin sensations, though such changes of pressure, if applied suddenly, are much above the threshold value for touch. A touch excited by constant mechanical pressure of slight intensity fades quickly below the threshold of sensation. Thus the almost unbearable discomfort which a child feels on putting on for the first time a "natural" wool vest fades away, and is no longer noticed with continual wear. Thomas à Becket soon must have become oblivious to his hair shirt, and even to its harbingers. It is not the wind which God tempers to the shorn lamb, but the skin of the lamb to the wind. The inflow of sensations keeps us active and alive and all the organs working in their appointed functions. The cutaneous sensations are of the highest importance. The salt and sand of wind-driven sea air particularly act on the skin and through it braces the whole body. The changing play of wind, of light, cold and warmth stimulate the activity and health of mind and body. Monotony of sedentary occupation and of an overwarm still atmosphere endured for long working hours destroys vigor and happiness and brings about the atrophy of disuse. We hear a great deal of the degeneration of the race brought about by city life, but observation shows us that a drayman, navvy or policeman can live in London, or other big city, strong and vigorous, and no less so than in the country. The brain-worker, too, can keep himself perfectly fit if his hours of sedentary employment are not too long and he balances these by open-air exercise. The horses stabled, worked and fed in London are as fine as any in the world; they do not live in windless rooms heated by radiators.

The hardy men of the north were evolved to stand the vagaries of climate—cold and warmth—a starved or full belly have been their changing lot. The full belly and the warm sun have expanded them in lazy comfort; the cold and the starvation have braced them to action. Modern civilization has withdrawn many of us from the struggle with the rigors of nature; we seek for and mostly obtain the

comfort of a full belly and expand all the time in the warm atmosphere afforded us by clothes, wind-protected dwellings and artificial heat—particularly so in the winter, when the health of the business man deteriorates. Cold is not comfortable, neither is hunger, therefore we are led to ascribe many of our ills to exposure to cold, and seek to make ourselves strong by what is termed good living. I maintain that the bracing effect of cold is of supreme importance to health and happiness, that we become soft and flabby and less resistant to the attacks of infecting bacteria in the winter not because of the cold but because of our excessive precautions to preserve ourselves from cold; that the prime cause of "cold" or "chill" is not really exposure to cold but to the over-heated and confined air of rooms, factories and meeting places. Seven hundred and eleven survivors were saved from the *Titanic* after hours of exposure to cold. Many were insufficiently clad and others wet to the skin. Only one died after reaching the *Carpathia,* and he three hours after being picked up. Those who died perished from actual cooling of the body. Exposure to cold did not cause in the survivors the diseases commonly attributed to cold.

Conditions of city and factory life diminish the physical and nervous energy, and reduce many from the vigorous health and perfectness of bodily functions which a wild animal possesses to a more secure, but poorer and far less happy, form of existence. The ill chosen diet, the monotony and sedentary nature of daily work, the windless uniformity of atmosphere, above all, the neglect of vigorous muscular exercise in the open air and exposure to the winds and light of heaven—all these, together with the difficulties in the way of living a normal sexual life, go to make the pale, undeveloped, neurotic and joyless citizen. Nurture in unnatural surroundings, not nature's birth-mark, molds the criminal and the wastrel. The environment of childhood and youth is at fault rather than the stock; the children who are taken away and trained to be sailors, those sent to agricultural pursuits in the colonies, those who become soldiers, may develop a physique and bodily health and vigor in striking contrast to their brothers who become clerks, shop assistants and compositors.

Too much stress can not be put on the importance of muscular exercise in regard to health, beauty and happiness. Each muscle fills with blood as it relaxes, and expels this blood on past the venous valves during contraction. Each muscle together with the venous valves forms a pump to the circulatory system. It is the function of the heart to deliver the blood to the capillaries, and the function of the muscles—visceral, respiratory and skeletal—to bring it back to the heart. The circulation is contrived for a restless mobile animal; every vessel is arranged so that muscular movement furthers the flow of blood.

The pressure of the blood in the veins and arteries under the influence of gravity varies with every change of posture. The respiratory pump, too, has a profound influence on the circulation. Active exercise, such as is taken in a game of football, entails endless changes of posture, varying compressive actions—one with another struggling in the rough and tumble of the game—forcible contractions and relaxations of the muscles, and a vastly increased pulmonary ventilation; at the same time the heart's action is accelerated and augmented and the arterial supply controlled by the vaso-motor system. The influence of gravity, which tends to cause the fluids of the body to sink into the lower parts, is counteracted; the liver is rhythmically squeezed like a sponge by the powerful respiratory movements, which not only pump the blood through the abdominal viscera, but thoroughly massage these organs, and kneading these with the omentum clean the peritoneal cavity and prevent constipation. At the same time the surplus food metabolic products, such as sugar and fat, stored in the liver, are consumed in the production of energy, and the organs swept with a rapid stream of blood containing other products of muscular metabolism which are necessary to the inter-relation of chemical action. The output of energy is increased very greatly; a resting man may expend two thousand calories per diem; one bicycling hard for most of the day expended eight thousand calories, of which only four thousand was covered by the food eaten.

Such figures show how fat is taken off from the body by exercise, for the other four thousand calories comes from the consumption of surplus food products stored in the tissues. While resting a man breathes some 7 liters of air, and uses 300 c.c. of oxygen per minute, against 140 liters and 3,000 c.c. while doing very hard labor. The call of the muscles for oxygen through such waste products as lactic acid impels the formation of red corpuscles and hemoglobin. The products of muscular metabolism in other ways not yet fully defined modify the metabolism of the whole body.

Exposure to cold, cold baths and cold winds has a like effect, accelerating the heart and increasing the heat production, the activity of the muscles, the output of energy, the pulmonary ventilation and intake of oxygen and food. In contrast with the soft pot-bellied, overfed city man the hard, wiry fisherman trained to endurance has no superfluity of fat or tissue fluid. His blood volume has a high relative value in proportion to the mass of his body. His superficial veins are confined between a taut skin and muscles, hard as in a race-horse trained to perfection. Thus the adequacy of the cutaneous circulation and loss of heat by radiation rather than by sweating is assured. His fat is of a higher melting-point, hardened by exposure to cold. In him less blood is derived to other parts such as adipose tissue, skin

and viscera. He uses up the oxygen in the arterial blood more completely and with greater efficiency; for the output of each unit of energy his heart has to circulate much less blood (Kreogh); his blood is sent in full volume by the well-balanced activity of his vasomotor system to the moving parts. Owing to the perfect coordination of his muscles, trained to the work, and the efficient action of his skin and cutaneous circulation—the radiator of the body—he performs the work with far greater economy and less fatigue. The untrained man may obtain 12 per cent. of his energy output as work, against 30 per cent. or perhaps even 50 per cent. obtained by the trained athlete. Hence the failure and risk suffered by the city man who rushes straight from his office to climb the Alps. On the other hand, the energetic man of business or brain worker is kept by his work in a state of nervous tension. He considers alternative lines of action, but scarcely moves. He may be intensely excited, but the natural muscular response does not follow. His heart is accelerated and his blood pressure raised, but neither muscular movements and accompanying changes of posture, nor the respiratory pump materially aid the circulation. The activity of his brain demands a rapid flow of blood, and his heart has to do the circulatory work, as he sits still or stands at his desk, against the influence of gravity. Hence a high blood pressure is maintained for long periods at a time by vaso-constriction of the arteries in the lower parts of the body and increased action of the heart; hence, perhaps, arise those degenerative changes in the circulatory system which affect some men tireless in their mental activity. We know that the bench-worker, who stands on one leg for long hours a day, may suffer from degeneration and varicosity of the veins in that leg. Long continued high arterial pressure, with systolic and diastolic pressures approximately the same, entails a stretched arterial wall, and this must impede the circulation in the vaso vasorum, the flow of tissue lymph in, and nutrition of, the wall. Since his sedentary occupation reduces the metabolism and heat production of his body very greatly, the business man requires a warmer atmosphere to work in. If the atmosphere is too warm it reduces his metabolism and pulmonary ventilation still further; thus he works in a vicious circle. Exhausting work causes the consumption of certain active principles, for example, adrenalin, and the reparation of those must be from the food. To acquire certain of the rarer principles expended in the manifestation of nervous energy more food may have to be eaten by the sedentary worker than can be digested and metabolized. His digestive organs lack the kneading and massage, the rapid circulation and oxidation of foodstuffs which is given by muscular exercise. Hence arise the digestive and metabolic ailments so common to brain workers.

Mr. Robert Milne informs me that of the thousands of children which have passed through Barnardo's Homes—there are 9,000 in the homes at any one time—not one after entering the institution and passing under its regimen and the care of his father, Dr. Milne, has developed appendicitis. Daily exercise and play, adequate rest, a regular simple diet have ensured their immunity from this infection. It pays to keep a horse healthy and efficient; it no less pays to keep men healthy. I recently investigated the case of clerks employed in a great place of business, whose working hours are from 9 to 6 on three days, and 7 to 9 on the other three days of each week, and, working such overtime, they make £1 to £2 a week; these clerks worked in a confined space—forty to fifty of them in 8,200 cubic feet, lit with thirty electric lamps, cramped for room, and overheated in warm summer days. It is not with the chemical purity of the air of such an office that fault is to be found, for fans and large openings ensured this sufficiently. These clerks suffered from their long hours of monotonous and sedentary occupation, and from the artificial light, and the windless, overwarm and moist atmosphere. Many a girl cashier has worked from 8 to 8:30, and on Saturdays from 8 to 10, and then has had to balance her books and leave perhaps after midnight on Sunday morning. Her office is away in the background—confined, windless, artificially lit. The Shops Act has given a little relief from these hours. What, I ask, is the use of the state spending a million a year on sanatoria and tuberculin dispensaries, when those very conditions of work continue which lessen the immunity and increase the infection of the workers?

The jute industry in this town of Dundee is carried out almost wholly by female and boy labor. "The average wages for women are below 12s. in eight processes and above 12s., but under 18s., for the remaining five processes." The infant mortality has been over 170 per 1,000. The Social Union of Dundee reported in 1905 that of 885 children born to 240 working mothers no fewer than 520, or 59 per cent., died—and almost all of them were under five years of age. The life of these mothers was divided between the jute factory and the one-roomed tenement. Looking such conditions squarely in the face, I say it would be more humane for the state to legalize the exposure of every other new-born infant on the hillside rather than allow children to be slowly done to death. The conditions as given in the report contravene those rights of motherhood which the meanest wild animal can claim.

Isolation hospitals, sputum-pots and anti-spitting regulations will not stamp out tuberculosis. Such means are like shutting the door of the stable when the horse has escaped. Flügge has shown that tubercle bacilli are spread by the droplets of saliva which are carried

out as an invisible spray when we speak, sing, cough, sneeze. Sputum-pots can not control this. The saliva of cases of phthisis may teem with the bacilli. The tuberculin reaction tests carried out by Hamburger and Monti in Vienna show that 94 per cent. of all children aged eleven to fourteen have been infected with tubercle. In most the infection is a mere temporary indisposition. I believe that the conditions of exhausting work, and amusement in confined and overheated atmospheres, together with ill-regulated feeding, determine largely whether the infection, which almost none can escape, becomes serious or not. Karl Pearson suggests that the death statistics afford no proof of the utility of sanatoria or tuberculin dispensaries, for during the very years in which such treatment has been in vogue, the fall in the mortality from tuberculosis has become less relatively to the fall in general mortality. He opines that the race is gradually becoming immune to tubercle, and hence the declination in the mortality curve is becoming flattened out—that nature is paramount as the determinant of tuberculosis, not nurture. From a statistical inquiry into the incidence of tuberculosis in husband and wife and parent and child Pearson concludes that exposure to infection as in married couples is of little importance while inborn immunity or diathesis is a chief determinant. Admitting the value of his critical inquiries and the importance of diathesis, I would point out that in the last few years the rush and excitement of modern city life has increased, together with the confinement of workers to sedentary occupations in artificially lit, warm, windless atmospheres. The same conditions pertain to places of amusement, eating-houses, tube railways, etc.

Central heating, gas-radiators and other contrivances are now displacing the old open fire and chimney. This change greatly improves the economical consumption of coal and the light and cleanliness of the atmosphere. But in so far as it promotes monotonous, windless, warm atmospheres, it is wholly against the health and vigor of the nation. The open fire and wide chimney ensure ventilation, the indrawing of cold outside air, streaky air—restless currents at different temperatures, which strike the sensory nerves in the skin and prevent monotony and weariness of spirit. By the old open fires we were heated with radiant heat. The air in the rooms was drawn in cool and varied in temperature. The radiator and hot-air system give us a deadly uniformly heated air—the very conditions we find most unsupportable on a close summer's day.

In Labrador and Newfoundland, Dr. Wakefield tells me, the mortality of the fisherfolk from tuberculosis is very heavy. It is generally acknowledged to be four per 1,000 of the population per annum, against 1.52 for England and Wales. Some of the Labrador doctors

talk of seven and even eight per 1,000 in certain districts. The general death-rate is a low one. The fishermen fish off shore, work for many hours a day in the fishing season, and live with their families on shore in one-roomed shanties. These shanties are built of wood, the crannies are "stogged" with moss, and the windows nailed up, so that ventilation is very imperfect. They are heated by stoves and kept at a very high temperature, *e. g.*, 80° F. Outside in the winter the temperature may be 30 degrees below freezing. The women stay inside the shanties almost all their time, and the tuberculosis rate is somewhat higher in them. The main food is white bread, tea stewed in the pot till black, fish occasionally, a little margarine and molasses. The fish is boiled and the water thrown away. Game has become scarce in recent years; old, dark-colored flour—spoken of with disfavor—has been replaced by white flour. In consequence of this diet beri-beri has become rife to a most serious extent, and the hospitals are full of cases. Martin Flack and I have found by our feeding experiments that rats, mice and pigeons can not be maintained on white bread and water, but can live on wholemeal, or on white bread in which we incorporate an extract of the sharps and bran in sufficient amount. Recent work has shown the vital importance of certain active principles present in the outer layers of wheat, rice, etc., and in milk, meat, etc., which are destroyed by heating to 120° C. A diet of white bread or polished rice and tinned food sterilized by heat is the cause of beri-beri. The metabolism is endangered by the artificial methods of treating foods now in vogue. As to the prevalency of tuberculosis in Labrador, we have to consider the inter-marriage, the bad diet, the over-rigorous work of the fishermen, the over-heating of, and infection in the shanties. Dr. Wakefield has slept with four other travelers in a shanty with father, mother and ten children. In some there is scarce room on the floor to lie down. The shanties are heated with a stove on which pots boil all the time; water runs down the windows. The patients are ignorant, and spit everywhere, on bed, floor and walls. In the schools the heat and smell is most marked to one coming in from the outside air. In one school 50 cubic feet per child is the allowance of space. The children are eating all day long, and are kept in close hot confinement. They suffer very badly from decay of the teeth. Whole families are swept off with tuberculosis, and the child who leaves home early may escape, while the rest of a family dies. Here, then, we have people living in the wildest and least populated of lands with the purest atmosphere suffering from all those ill-results which are found in the worst city slums—tuberculosis, beri-beri and decayed teeth.

The bad diet probably impels the people to conserve their body heat and live in the over-warm, confined atmosphere, just as our

pigeons fed on white bread sit, with their feathers out, huddled together to keep each other warm.

The metabolism, circulation, respiration and expansion of the lung are all reduced. The warm, moist atmosphere lessens the evaporation from the respiratory tract, and therefore the transudation of tissue lymph and activity of the ciliated epithelium. The unexpanded parts of the lung are not swept with blood. Everything favors a lodgment of the bacilli, and lessens the defences on which immunity depends. In the mouth, too, the immune properties of the saliva are neutralized by the continual presence of food, and the temperature of the mouth is kept at a higher level, which favors bacterial growth. Lieutenant Siem informs me that recently in northern Norway there has been the same notable increase in tuberculosis. The old cottage fireplaces with wide chimneys have been replaced with American stoves. In olden days most of the heat went up the chimney, and the people were warmed by radiant heat. Now the room is heated to a uniform moist heat. The Norwegians nail up the windows and never open them during the winter. At Lofoten, the great fishing center, motor-boats have replaced the old open sailing and row boats. The cabin in the motor-boat is very confined, covered in with watertight deck, heated by the engine, crowded with a dozen workers. When in harbor the fishermen used to occupy ill-fitted shanties, through which the wind blew freely; now, to save rent, they sleep in the motor-boat cabins. Here, again, we have massive infection, and the reduction of the defensive mechanisms by the influence of the warm, moist atmosphere.

The Norwegian fishermen feed on brown bread, boiled fish, salt mutton, margarine, and drink, when in money, beer and schnapps; there is no gross deficiency in diet, as in Labrador, and beri-beri does not attack them. They return home to their villages and longshore fishing when the season is over. The one new condition which is common to the two districts is confinement in stove-heated, windless atmospheres. In old days the men were crowded together, but in open boats or in draughty shanties, and had nothing but little cooking-stoves.

The conditions of great cities tend to confine the worker in the office all day, and to the heated atmosphere of club, cinema show or music-hall in the evening. The height of houses prevents the town dweller from being blown upon by the wind, and, missing the exhilarating stimulus of the cool, moving air, he repels the dull uniformity of existence by tobacco and by alcohol, or by indulgence in food, *e. g.*, sweets, which are everywhere to his hand, and by the nervous excitement of business and amusement. He works, he eats, and is amused in warm, windless atmospheres, and suffers from a feeble circulation,

a shallow respiration, a disordered digestion and a slow rate of metabolism.

Many of the employments of modern days are detestable in their long hours of confinement and monotony. Men go up and down in a lift all day, and girls in the bloom of youth are set down in tobacco stalls in underground stations, and their health and beauty there fade while even the blow-flies are free to bask in the sun. In factories the operatives feed machines, or reproduce the same small piece of an article day after day. There is no art, or change, no pleasure in contrivance and accomplishment. The miner, the fisherman, even the sewerman, face difficulties, changing risks, and are developed as men of character and strength. Contrast the sailor with the steward on a steamer, the drayman outside with the clerk inside who checks the goods delivered at some city office, the butcher and the tailor, the seamstress and the market woman, and one sees the enormous difference which a confined occupation makes. Monotonous sedentary employment makes for unhappiness because the inherited functional needs of the human body are neglected, and education—when the outside field of interest is narrowed—intensifies the sensitivity to the bodily conditions. The sensations arising within the body—proprioceptive sensations—come to have too large a share in consciousness in comparison with exteroceptive. In place of considering the lilies how they grow or musing on the beauty and motions of the heavenly bodies, the sedentary worker in the smoke-befouled atmosphere, with the limited activity and horizon of an office and a disturbed digestion, tends to become confined to the inward consideration of his own viscera and their motions.

Many of the educated daughters of the well-to-do are no less confined at home; they are the flotsam and jetsam cast up from the tide in which all others struggle for existence—their lives are no less monotonous than the sweated seamstress or clerk. They become filled with "vapors" and some seek excitement not in the cannon's mouth, but in breaking windows, playing with fire, and hunger strikes. The dull monotony of idle social functions, shopping and amusement no less than that of sedentary work and an asexual life, impels to a simulated struggle—a theatrical performance, the parts of which are studied from the historical romances of revolution. Each man, woman and child in the world must find the wherewithal for living, food, raiment, warmth and housing, or must die or get some other to find it for him. It seems to me as if the world is conducted as if ten men were on an island—a microcosm—and five sought for the necessaries of life, hunted for food, built shelters and fires, made clothes of skins, while the other five strung necklaces of shells, made loin-cloths of butterfly wings, gambled with knuckle-bones, drew comic pictures

in the sand, or carved out of clay frightening demons, and so beguiled from the first five the larger share of their wealth. In this land of factories, while the many are confined to mean streets and wretched houses, possessing no sufficiency of baths and clean clothing, and are ill-fed, they work all day long, not to fashion for themselves better houses and clothing, but to make those unnecessaries such as "the fluff" of women's apparel and a thousand trifles which relieve the monotony of the idle and bemuse their own minds.

The discovery of radium and its disintegration as a source of energy has enabled the physicist to extend Lord Kelvin's estimate of the world's age from some thirty to a thousand million years. Arthur Keith does not hesitate to give a million of these years to man's evolution. Karl Pearson speaks of hundreds of thousands of years. The form of the human skull, the brain capacity of man, his skill as evidenced by stone implements and cave drawings of animals in action, was the same tens of thousands of years ago as now. For ages primitive man lived as a wild animal in tropical climes, discovered how to make fire, clothe himself in skins, build shelters, and so enable himself to wander over the temperate and arctic zones. Finally, in the last few score of years, he has made houses draughtless with glass windows, fitted them with stoves and radiators and every kind of device to protect himself from cold, while he occupies himself in the sedentary pursuits and amusements of a city life. How much better, to those who know the boundless horizon of life, to be a frontiers-man and enjoy the struggle, with body hardened, perfectly fit, attuned to nature, than to be a cashier condemned to the occupation of a sunless, windless pay-box. The city child, however, nurtured and educated in confinement, knows not the largeness and wonders of nature, is used to the streets with their ceaseless movement and romantic play of artificial light after dark, and does not need the commiseration of the country mouse any more than the beetle who lives in the dark and animated burrows of his heap. But while outdoor work disciplines the body of the countryman into health, the townman needs the conscious attention and acquired educated control of his life to give him any full measure of health and happiness.

Experimental evidence is strongly in favor of my argument that the chemical purity of the air is of no importance. Analyses show that the oxygen in the worst-ventilated school-room, chapel or theater is never lessened by more than 1 per cent. of an atmosphere; the ventilation through chink and cranny, chimney, door and window, and the porous brick wall, suffices to prevent a greater diminution. So long as there is present a partial pressure of oxygen sufficient to change the hemoglobin of the venous blood into oxyhemoglobin there can arise no lack of oxygen.

At sea-level the pressure of oxygen in the pulmonary alveolar air is about 100 mm. Hg. Exposed to only half this pressure the hemoglobin is more than 80 per cent. saturated with oxygen.

In noted health resorts of the Swiss mountains the barometer stands at such a height that the concentration of oxygen is far less than in the more ventilated room. On the high plateau of the Andes there are great cities: Potosi with a hundred thousand inhabitants is at 4,165 meters, and the partial pressure of oxygen there is about 13 per cent. of an atmosphere in place of 71 per cent. at sea-level; railways and mines have been worked up to altitudes of 14,000 to 15,000 feet. At Potosi girls dance half the night, and toreadors display their skill in the ring. On the slopes of the Himalayas shepherds take their flocks to altitudes of 18,000 feet. No disturbance is felt by the inhabitants or those who reach these great altitudes slowly and by easy stages. The only disability to a normal man is diminished power for severe exertion, but a greater risk arises from want of oxygen to cases of heart disease, pneumonia, and in chloroform anesthesia at these high altitudes. The newcomer who is carried by the railway in a few hours to the top of Pikes Peak or the Andes may suffer severely from mountain sickness, especially on exertion, and the cause of this is want of oxygen. Acclimatization is brought about in a few days' time. The pulmonary ventilation increases, the bronchial tubes dilate, the circulation becomes more rapid. The increased pulmonary ventilation lowers the partial pressure of carbon dioxide in the blood and pulmonary air, and this contributes to the maintenance of an adequate partial pressure of oxygen. Haldane and Douglas say that the percentage of red corpuscles and total quantity of the hemoglobin increases, and maintain that the oxygen is actively secreted by the lung into the blood, but the C method by which their determinations have been made has not met with unqualified acceptance. If waste products, which arise from oxygen want, alter the combining power of hemoglobin, this alteration may not persist in shed blood; for these products may disappear when the blood is exposed to air. Owing to the combining power of hemoglobin the respiratory exchange and metabolism of an animal within wide limits is independent of the partial pressure of oxygen. On the other hand, the process of combustion is dependent not on the pressure but on the percentage of oxygen. Thus the aeroplanist may become seized with altitude sickness from oxygen want, while his gas engine continues to carry him to loftier heights.

The partial pressure of oxygen in a mine at a depth of 3,000 feet is considerably higher than at sea-level, and if the percentage is reduced to 17, while the firing of fire-damp and coal dust is impossible, there need be in the alveolar air of the lungs no lower pressure of oxygen than at sea-level. Thus the simplest method of preventing

explosions in coal mines is that proposed by J. Harger, viz., to ventilate them with air containing 17 per cent. of oxygen.[2] There is little doubt that all the great mine-explosions have been caused by the enforcement of a high degree of chemical purity of the air. In the old days when ventilation was bad there were no great dust explosions. Mr. W. H. Chambers, general manager of the Cadeby mine, where the recent disastrous explosion occurred, with the authority of his great and long practical experience of fiery mines, told me that the spontaneous combustion of coal and the danger of explosion can be wholly met by adequate diminution in ventilation. The fires can be choked out while the miners can still breathe and work. The Coal Mines Regulation Act enforces that a place shall not be in a fit state for working or passing therein, if the air contains either less than 19 per cent. of oxygen, or more than 1¼ per cent. of carbon dioxide. A mine liable to spontaneous combustion of coal may be exempted from this regulation by order of the Secretary of State.

The regulations impel the provision of such a ventilation current that the percentage of oxygen is sufficient for the spread of dust explosions along the intake airways, with the disastrous results so frequently recorded. If the mine were ventilated with air containing 17 per cent. of oxygen in sufficient volume to keep the miners cool and fresh, not only would explosions be prevented, but the mines could be safely worked and illuminated with electricity, and miners' nystagmus prevented, for this is due to the dim light of the safety lamp. The problem possibly may be solved by purifying and cooling the return air, and mixing and circulating this with a sufficiency of fresh air.

Owing to the fact that the percentage of CO_2 is the usual test of ventilation and that only a very few parts per 10,000 in excess of fresh air are permitted by the English Factory Acts, it is generally supposed that CO_2 is a poison and that any considerable excess has a deleterious effect on the human body. No supposition could be further from the truth.

The percentage of CO_2 in the worst ventilated room does not rise above 0.5 per cent., or at the outside 1 per cent. It is impossible that any excess of CO_2 should enter into our bodies when we breathe such air, for whatever the percentage of CO_2 in the atmosphere may be, that in the pulmonary air is kept constant at about 5 to 6 per cent. of an atmosphere—by the action of the respiratory center. It is the concentration of CO_2 which rules the respiratory center, and to such purpose as to keep the concentration both in the lungs and in the blood uniform (Haldane); the only result from breathing air containing 0.5 to 1 per cent. of CO_2 is an inappreciable increase in the ventila-

[2] *Trans. Inst. of Mining Engineers*, 1912.

tion of the lungs. The very same thing happens when we take gentle exercise and produce more CO_2 in our bodies.

At each breath we rebreathe into our lungs the air in the nose and large air-tubes (the dead-space air), and about one third of the air which is breathed in by a man at rest in dead-space air. Thus, no man breathes in pure outside air into his lungs. When a child goes to sleep with its head partly buried under the bed-clothes, and in a cradle confined by curtains, he rebreathes the expired air to a still greater extent, and so with all animals that snuggle together for warmth's sake. Not only the new-born babe sleeping against its mother's breast, but pigs in a sty, young rabbits, rats and mice clustered together in their nests, young chicks under the brooding hen, all alike breathe a far higher percentage than that allowed by the Factory Acts. To rebreathe one's own breath is a natural and inevitable performance, and to breathe some of the air exhaled by another is the common lot of men who, like animals, have to crowd together and husband their heat in fighting the inclemency of the weather.

In the Albion Brewery we analyzed on three different days the air of the room where the CO_2 generated in the vats is compressed and bottled as liquid carbonic acid. We found from 0.14 to 0.93 per cent. of CO_2 in the atmosphere of that room. The men who were filling the cylinders and turning the taps on and off to allow escape of air must often breathe more than this. The men engaged in this occupation worked twelve-hour shifts, having their meals in the room. Some had followed the same employment for eighteen years, and without detriment to their health. It is only when the higher concentrations of CO_2 are breathed, such as 3 to 4 per cent. of an atmosphere, that the respiration is increased, so that it is noticeable to the resting individual; but percentages over 1 per cent. diminish the power to do muscular work, for the excess of CO_2 produced by the work adds its effect to that of the excess in the air, and the difficulty of coordinating the breathing to the work in hand is increased.

Haldane and Priestley found that with a pressure of 2 per cent. of an atmosphere of CO_2 in the inspired air the pulmonary ventilation of a man at rest was increased 50 per cent., with 3 per cent. about 100 per cent., with 4 per cent. about 200 per cent., with 5 per cent. about 300 per cent. and with 6 per cent. about 500 per cent. With the last, panting is severe, while with 3 per cent. it is unnoticed until muscular work is done, when the panting is increased 100 per cent. more than usual. With more than 6 per cent. the distress is very great, and headache, flushing and sweating occur.

Divers who work in diving dress and men who work in compressed air caissons constantly do heavy and continuous labor in concentrations of CO_2 higher than 1 per cent. of an atmosphere, and so long as the

CO_2 is kept below 2 to 3 per cent. they are capable of carrying out efficient work. In the case of workers in compressed air it is important to bear in mind that the effect of the CO_2 on the breathing depends on the partial pressure and not on the percentage of this gas in the air breathed.

By a series of observations made on rats confined in cages fitted with small, ill-ventilated sleeping chambers, we have found that the temperature and humidity of the air—not the percentage of carbon dioxide or oxygen—determines whether the animals stay inside the sleeping room or come outside. When the air is cold, they like to stay inside, even when the carbon dioxide rises to 4 to 5 per cent. of an atmosphere. When the sleeping chamber is made too hot and moist they come outside.

The sanitarian says it is necessary to keep the CO_2 below 0.01 per cent., so that the organic poisons may not collect to a harmful extent. The evil smell of crowded rooms is accepted as unequivocal evidence of the existence of such. He pays much attention to this and little or none to the heat and moisture of the air. The smell arises from the secretions of the skin, soiled clothes, etc. The smell is only sensed by and excites disgust in one who comes to it from the outside air. He who is inside and helps to make the "fugg" is both wholly unaware of and unaffected by it. Flügge points out, with justice, that while we naturally avoid any smell that excites disgust and puts us off our appetite, yet the offensive quality of the smell does not prove its poisonous nature. For the smell of the trade or food of one man may be horrible and loathsome to another not used to such.

The sight of a slaughterer and the smell of dead meat may be loathly to the sensitive poet, but the slaughterer is none the less healthy. The clang and jar of an engineer's workshop may be unendurable to a highly strung artist or author, but the artificers miss the stoppage of the noisy clatter. The stench of glue-works, fried-fish shops, soap and bone-manure works, middens, sewers, become as nothing to those engaged in such, and the lives of the workers are in no wise shortened by the stench they endure. The nose ceases to respond to the uniformity of the impulse, and the stench clearly does not betoken in any of these cases the existence of a chemical organic poison. On descending into a sewer, after the first ten minutes the nose ceases to smell the stench; the air therein is usually found to be far freer from bacteria than the air in a school-room or tenement.

If we turn to foodstuffs we recognize that the smell of alcohol and of Stilton or Camembert cheese is horrible to a child, while the smell of putrid fish—the meal of the Siberian native—excites no less disgust in an epicure, who welcomes the cheese. Among the hardiest and healthiest of men are the North Sea fishermen, who sleep in the cabins

of trawlers reeking with fish and oil, and for the sake of warmth shut themselves up until the lamp may go out from want of oxygen. The stench of such surrounding may effectually put the sensitive, untrained brain worker off his appetite, but the robust health of the fisherman proves that this effect is nervous in origin, and not due to a chemical organic poison in the air.

Ventilation can not get rid of the source of a smell, while it may easily distribute the evil smell through a house. As Pettenkofer says, if there is a dung-heap in a room, it must be removed. It is no good trying to blow away the smell.

Flügge and his school bring convincing evidence to show that a stuffy atmosphere is stuffy owing to heat stagnation, and that the smell has nothing to do with the origin of the discomfort felt by those who endure it. The inhabitants of reeking hovels in the country do not suffer from chronic ill-health, unless want of nourishment, open-air exercise, or sleep come into play. Town workers who take no exercise in the fresh air are pale, anemic, listless. Sheltered by houses they are far less exposed to winds, and live day and night in a warm, confined atmosphere.

The widespread belief in the presence of organic poisons in the expired air is mainly based on the statements of Brown Sequard and D'Arsenval, statements wholly unsubstantiated by the most trustworthy workers in Europe and America. These statements have done very great mischief to the cause of hygiene, for they led ventilating engineers and the public to seek after chemical purity, and neglect the attainment of adequate coolness and movement of the air. It was stated that the condensation water obtained from expired air is poisonous when injected into animals. The evidence on which this statement is based is not only not worthy of credence but is absurd, *e. g.*, condensation water has been injected into a mouse in a quantity equivalent to injecting 5 kilograms into a man weighing 60 kilograms. No proper controls were carried out. It is recognized now that any distilled water contaminated by bacterial products may have a toxic effect. Flack and I have for fourteen weeks kept guinea-pigs and rats confined together in a box and poorly ventilated, so that they breathed air containing 0.5 to 1.0 per cent. of CO_2. The guinea-pigs proved wholly free from anaphylactic shock on injecting rat's serum. Therefore they were not sensitized by breathing the exhaled breath of the rats for many weeks, and we are certain that no foreign protein substance is absorbed in this way. It has been proved by others, and by us, that animals so confined do well so long as they are well fed and their cages kept clean, light, cool and dry. It is wholly untrue that they are poisoned by breathing each other's breath. The only danger arises from droplet contagion in cases of infective disease.

To study the relative effect of the temperature and chemical purity of the atmosphere I constructed a small experimental chamber of wood fitted with large glass observation windows and rendered air-tight.

On one side of the chamber were fixed two small electric heaters, and a tin containing water was placed on these in order to saturate the air with water vapor. On another side of the chamber was placed a large radiator through which cold water could be circulated when required, so as to cool the chamber. In the roof were fixed three electric fans, one big and two small, by means of which the air of the chamber could be stirred. The chamber held approximately 3 cm. of air. In one class of experiments we shut within the chamber seven or eight students for about half an hour, and observed the effect of the confined atmosphere upon them. We kept them until the CO_2 reached 3 to 4 per cent., and the oxygen had fallen to 17 to 16 per cent. The wet-bulb temperature rose meanwhile to about 80° to 85° F., and the dry bulb a degree or two higher. The students went in chatting and laughing, but by-and-by, as the temperature rose, they ceased to talk and their faces became flushed and moist. To relieve the monotony of the experiment we have watched them trying to light a cigarette, and, puzzled by their matches going out, borrowing others, only in vain. They had not sensed the diminution of oxygen, which fell below 17 per cent. Their breathing was deepened by the high percentage of CO_2, but no headache occurred in any of them from the short exposure. Their discomfort was relieved to an astonishing extent by putting on the electric fans placed in the roof. Whilst the air was kept stirred the students were not affected by the oppressive atmosphere. They begged for the fans to be put on when they were cut off. The same old stale air containing 3 to 4 per cent. CO_2 and 16 to 17 per cent. O_2 was whirled, but the movement of the air gave relief, because the air was 80° to 85° F. (wet bulb), while the air enmeshed in their clothes in contact with their skin was 98° to 99° F., wet bulb. If we outside breathed through a tube the air in the chamber we felt none of the discomfort which was being experienced by those shut up inside. Similarly, if one of those in the chamber breathed through a tube the pure air outside he was not relieved.

R. A. Rowlands and H. B. Walker carried out a large number of observations in the chamber, each acting as subject in turn. They recorded the effect on the respiratory ventilation and on the pulse rate both when resting and when working. The work consisted in pulling a 20-kilogram weight about 1 meter high by means of a pulley and rope. In some of the experiments the exhaled carbonic acid was absorbed, and in others carbonic acid was put into the chamber. The subjects inside could not tell when the gas was introduced, not even if the percentage were suddenly raised by 2. The introduction of this

amount of the gas made no sensible difference to them, but increased their pulmonary ventilation. In every one of the experiments they suffered from the heat, and the putting on of the fans gave great relief, and in particular diminished the pulse rate during and after the working periods. The relief became much greater when cold water was circulated through the radiator and the temperature of the chamber lowered 10° F. The subjects wore only a vest, pants and shoes in most of these experiments. When they wore their ordinary clothing the effect on the frequency of the pulse was more marked and the discomfort from heat and moisture much greater.

I have made observations on men dressed in the Fleuss rescue apparatus for use in mines, and exposed in a chamber to 120° F. dry bulb and 95° F. wet bulb. The skin temperature rises to the rectal temperature and the pulse is greatly accelerated—*e. g.*, to 150—and there arises danger of heat stroke. The conditions are greatly relieved by interposing on the inspiratory tube of the apparatus a cooler filled with carbonic-acid snow. The cool inspired air lowers the frequency of the heart and makes it possible for the men to do some work at 95° F. wet bulb, and to endure this temperature for two hours.

The observations made by Pembrey and Collis on the weaving-mill operatives at Darwen show that the skin of the face may be 4° to 13° F. higher in the mill when the wet bulb is 71° F. than at home when the wet-bulb temperature is about 55° F. The tendency of the warm, humid atmosphere of the mill is to establish a more uniform temperature of the body as a whole (surface and deep temperatures) and to throw a tax upon the power of accommodation as indicated by the rapid pulse and low blood-pressure.

The mill-workers are wet with the steam blown into the sheds, their clothes and bodies are moist, and the long hours of exposure to such uncomfortable conditions are most deleterious to physical vigor and happiness. The operatives asked that they might be allowed to work without steam-injectors and with diminished ventilation, so that the mill rooms became saturated with moisture evaporated from the bodies of the operatives. The old regulations, while forbidding more than 6 parts in 10,000 CO_2, put no limit to the wet-bulb temperature, and this often became excessive on hot summer days. The operatives were quite right. Less ventilation and a lower wet bulb is far better than ample ventilation and a high wet bulb. The permissible limit of CO_2 has now been raised to 11 parts in 10,000, and the wet-bulb temperature is to be controlled within reasonable limits.

The efficiency of workers in mills, mines, tunnels, stoke-holes, etc., is vastly increased by the provision of a sufficient draught of cool and relatively dry air, so as to prevent over-taxing of the heat-regulating mechanism. Mr. F. Green informs me that by means of forced

draught the stoke-hole of an Orient steamer is rendered the coolest place when the ship is in the tropics. The electric fan has vastly improved the conditions of the worker in the tropics. I would suggest that each clerk should have a fan just as much as a lamp on his desk. It will pay the employer to supply fans.

In the modern battleship men are confined very largely to places artificially lit and ventilated by air driven in by fans through ventilating shafts. The heat and moisture derived from the bodies of the men, from the engines, from cooking-ranges, etc., lead to a high degree of relative moisture, and thus all parts of the ironwork inside are coated with granulated cork to hold the condensed moisture and prevent dripping.

The air smells with the manifold smells of oil, cooking, human bodies, etc., and the fresh air driven in by fans through the metal conduits takes up the smell of these, and is spoken of by the officers with disparagement as "tinned" or "potted" air. This air is heated when required by being made to pass over radiators. Many of the officers' cabins and offices for clerks, typewriters, etc., in the center of the battleship, have no portholes, and are only lit and ventilated by artificial means. The steel nature of the structure prevents the diffusion of air which takes place so freely through the brick walls of a house. The men in their sleeping quarters are very closely confined, and as the openings of the air-conduits are placed in the roof between the hammocks, the men next to such openings receive a cold draught and are likely to shut the openings. To sleep in a warm moist "fugg" would not much matter if the men were actively engaged for many hours of the day on deck and there exposed to the open air and the rigors of sea and weather. In the modern warship most of the crew work for many hours under deck, and some of the men may scarcely come on deck for weeks or even months. Considering the conditions which pertain, it seems to be of the utmost importance that all the men in a battleship should be inspected at short intervals by the medical officers so that cases of tuberculosis may be weeded out in their incipiency. The men of every rating should do deck drill for some part of every day. In the Norwegian navy every man, cooks and all, must do gymnastic drill on deck once a day. In the case of our navy, with voluntary service, the men should welcome this in their own interest.

In a destroyer visited by me twelve men occupied quarters containing about 1,700 cubic feet of air. There was a stove with iron pipe for chimney, from which fumes of combustion must leak when in use, and a fan which would not work. When the men are shut down the moisture is such that boots, etc., go moldy, and the water drips off the structure. The cooling effect of the sea-water washing over the steel shell of the boat is beneficial in keeping down the temperature in these

confined and ill-ventilated quarters. On the maneuvering platform in the engine-room the wet-bulb temperature reaches a very high degree owing to the slight escape of steam round the turbines. Commander Domvile was kind enough to send me the wet and dry bulb temperatures taken there on a number of days. The wet bulb was found to be never below 80° F., sometimes reached 95° and even 98° F. It is impossible for officers to work at these temperatures without straining the heat-regulating mechanism of the body and diminishing their health and working capacity. If such wet-bulb temperatures are unavoidable, means should be provided, such as fans, which would alleviate the discomfort and fatigue caused thereby. A supply of compressed air fitted with a nozzle might be arranged and used occasionally to douche the body with cool air. I have tried this plan and found it very effectual, and can recommend the compressed-air bath as the substitute for a bracing cold wind.

The suitability of the clothing is of the greatest importance, not only to the comfort but to the efficiency of man as a working machine, *e. g.,* power of soldiers to march. On a still day the body is confined by the clothes as if by a chamber of stagnant air, for the air is enclosed in the meshes of the clothes and the layer in contact with the skin becomes heated to body temperature and saturated with moisture.

The observations of Pembrey show that himself and four soldiers, marching in drill order on a moderately warm day, lost more water and retained more water in their clothes than on another similar day when they worked with no jacket on. The average figures were loss of moisture 1,600, against 1,200 grams, and water retained in clothes 254, against 109 grams. With no jacket the pulse was, on the average, increased 28, against 41 in drill order, and rectal temperature 1°, against 1°.5 F. The taking off of the jacket or throwing open of the jacket and vest very greatly increase the physiological economy of a march. It is absurd that on a hot summer day Boy Scouts should march with a colored scarf knotted round their necks. Nothing should be worn for ornament or smartness which increases the difficulty of keeping down the body temperature. The power to march and the efficiency of an army depend on prevention of heart stagnation and avoidance of fatigue of the heart.

I conclude then, that all the efforts of the heating and ventilating engineer should be directed towards cooling the air in crowded places and cooling the bodies of the people by setting the air in motion by means of fans. In a crowded room the air confined between the bodies and clothes of the people is almost warmed up to body temperature and saturated with moisture so that cooling of the body by radiation, convection and evaporation becomes reduced to a minimum. The strain on the heat-regulating mechanism tells on the heart. The pulse

is accelerated, the blood is sent in increased volume to the skin, and circulates there in far greater volume, while less goes through the viscera and brain. As the surface temperature rises, the cutaneous vessels dilate, the veins become filled, the arteries may become small in volume, and the blood-pressure low, the heart is fatigued by the extra work thrown upon it. The influence of the heat stagnation is shown by the great acceleration of the pulse when work is done and the slower rate at which the pulse returns to its former rate on resting.

The increased percentage of carbonic acid and diminution of oxygen which has been found to exist in badly ventilated churches, schools, theaters, barracks, is such that it can have no effect upon the incidence of respiratory disease and higher death-rate, which statistical evidence has shown to exist among persons living in crowded and unventilated rooms. The conditions of temperature, moisture and windless atmosphere in such places primarily diminishes the heat loss, and secondarily the heat production, *i. e.*, the activity of the occupants, together with total volume of air breathed, oxygen taken in and food eaten. The whole metabolism of the body is thus run at a lower plane, and the nervous system and tone of the body is unstimulated by the monotonous, warm and motionless air. If hard work has to be done it is done under conditions of strain. The number of pathogenic organisms is increased in such places, and these two conditions run together—diminished immunity and increased mass influence of infecting bacteria.

The volume of blood passing through, and of water vapor evaporated from, the respiratory mucous membrane must have a great influence on the mechanisms which protect this tract from bacterial infection. While too wet an atmosphere lessens evaporation, a hot dry atmosphere dries up the mucous membrane. As the immunizing powers depend on the passage of blood plasma into the tissue spaces, it is clear that a proper degree of moisture is important. The temperature, too, must have a great influence on the scavenger activity of the ciliated epithelium and leucocytes in the mucous membrane of the nose.

In the warm moist atmosphere of a crowded place the infection from spray, sneezed, coughed, or spoken out, is enormous. On passing out from such an atmosphere into cold moist air the respiratory mucous membrane of the nose is suddenly chilled, the blood-vessels constricted and the defensive mechanism of cilia and leucocyte checked. Hence the prevalence of colds in the winter. In the summer the infection is far less. We are far more exposed to moving air, and the sudden transition from a warm to a cold atmosphere does not occur. We believe that infection is largely determined by (1) the mass influence of the infecting agent; (2) the shallow breathing and diminished

evaporation from, and flow of tissue lymph through, the respiratory tract, in warm, moist confined air. Colds are not caught by exposure to cold *per se,* as is shown by the experience of Arctic explorers, sailors, shipwrecked passengers, etc.

We have very great inherent powers of withstanding exposure to cold. The bodily mechanisms become trained and set to maintain the body heat by habitual exposure to open-air life. The risk lies in overheating our dwellings and over-clothing our bodies, so that the mechanisms engaged in resisting infection become enfeebled, and no longer able to meet the sudden transition from the warm atmosphere of our rooms to the chill outside air of winter. The dark and gloomy days of winter confine us within doors, and, by reducing our activity and exposure to open air, depress the metabolism; the influence of smoke and fog, gloom of house and streets, cavernous places of business and dark dwellings, intensify the depression. The immunity to a cold after an infection lasts but a short while, and when children return, after the summer holidays, to school and damp chill autumn days, infection runs around. The history of hospital gangrene and its abolition by the aseptic methods of Lister—likewise the history of insect-borne disease—show the great importance of cleanliness in crowded and much occupied rooms. The essentials required of any good system of ventilation are then (1) movement, coolness, proper degree of relative moisture of the air; (2) reduction of the mass influence of pathogenic bacteria. The chemical purity of the air is of very minor importance, and will be adequately insured by attendance to the essentials.

As the prevention of spray (saliva) infection by ventilation is impossible in crowded places, it behooves us to maintain our immunity at a high level. We may seek to diminish the spray output of those infected with colds by teaching them to cough, sneeze and talk with a handkerchief held in front of the mouth or to stay at home until the acute stage is past.

In all these matters nurture is of the greatest importance, as well as nature. A man is born with physical and mental capacities small or great, with inherited characteristics, with more or less immunity to certain diseases, with a tendency to longevity of life or the opposite, but his comfort and happiness in life, the small or full development of his physical and mental capacities, his immunity and his longevity of life, are undoubtedly determined to a vast extent by nurture. By nurture—use the the word in its widest sense to include all the defensive methods of sanitary science—plague, yellow fever, malaria, sleeping-sickness, cholera, hospital gangrene, etc., can be prevented by eliminating the infecting cause; smallpox and typhoid by this means, and also by vaccination; and most of the other ills which flesh is sup-

posed to be heir to can be kept from troubling by approximating to the rules of life which a wild animal has to follow in the matter of a simple, and often spare diet, hard exercise and exposure to the open air. There is nothing more fallacious than the supposition commonly held that over-feeding and over-coddling indoors promotes health. The two together derange the natural functions of the body. He who seeks to save his life will lose it.

The body of a new-born babe is a glorious and perfect machine, the heritage of millions of years of evolution.

> Not in entire forgetfulness,
> And not in utter nakedness,
> But trailing clouds of glory do we come.
>
> . . . . . .
>
> Shades of the prison house begin to close
> Upon the growing Boy.

The ill-conditioned body, anemic complexion and undersized muscles, or the fat and gross habit, the decay of the teeth, the disordered digestion, the nervous irritability and unhappiness are the result of "nurture"—not nature. In institutions children may be disciplined to vigorous health. After leaving school they are set adrift to face monotonous work in confined places, amusement in music-halls and cinema shows in place of manly exercise in the open air, injudicious diet, alcohol and tobacco—everything which the trainer of an athlete would repel.

> And custom lie upon thee with a weight
> Heavy as frost and deep almost as life.

THE PERMANENT FIREPROOFING OF COTTON GOODS[1]

By Professor WILLIAM HENRY PERKIN
UNIVERSITY OF MANCHESTER

WHEN I had the honor of being asked to deliver one of the general lectures, I had no choice but to accept and yet it was at once evident to me that I should experience very great difficulty in finding a subject suitable to this occasion and interesting to the brilliant and distinguished audience which I see before me this afternoon.

This difficulty is due to the fact that, while I have always taken an interest in industrial questions and have repeatedly investigated industrial problems from the scientific point of view, my researches have, for the most part, lain in the path of pure science, and any practical application of my researches to the chemical and allied industries, I have had to leave to others.

Among the problems of technical interest which I have worked at during many years are the manufacture of artificial camphor, of "synthetic" rubber and more particularly the permanent fireproofing of cotton goods and other inflammable materials. In considering these subjects, I concluded that the problem of the manufacture of artificial camphor was too technical to be generally interesting and my friend—Professor Duisberg—wishes to introduce the subject of "synthetic" rubber into his general lecture so there remained the subject of permanent fireproofing which in many respects is perhaps as interesting and important and as difficult of accomplishment as the other problems I have mentioned. The problem of the prevention of fire has always been one of the most pressing and at the same time one of the most difficult and perplexing with which mankind has had to deal. In very early times wooden houses caught fire and were burnt down and it is said that the Romans attempted to render wood fireproof by dipping it in a bath made of vinegar and powdered clay.

This treatment, so strongly reminiscent of processes employed many years afterwards, would no doubt be effective in rendering the wood less liable to inflame, but it can hardly have had wide application because vinegar, in those days, was not easily obtained in quantity and was consequently an expensive substance. I have made a search in a number of old books with the object of discovering some other of the actual methods used in early times in connection with fireproofing and the first pamphlet on the subject which I have been able to find dates from

[1] A general lecture before the Eighth International Congress of Applied Chemistry on September 10, 1912.

1638 when Nikolas Sabattini published a remarkable paper in which he discussed the need of reform in the administration and construction of the theaters in Italy and pointed out the danger, which is always present, of fire breaking out on the stage, not only owing to the inflammable nature of the wood employed in the construction of the theater and for the decorations and scenery but also on account of the inflammability of the cotton material used in the scenery and for the dresses of the players.

He recommends, as a safeguard, that the color used in painting the theater and scenery should be mixed with clay and gypsum but says nothing about the fireproofing of the dresses.

At a considerably later date—in 1735—Wild suggested a mixture of alum, borax and sulphuric acid for the same purpose and, in 1740, Fagot, in a paper read before the Academy in Stockholm, recommended a mixture of alum and green vitriol whereas, in the Dictionnaire de l'Industrie published in the year 1786, there is a paragraph in which it is stated that a mixture of alum, green vitriol and salt is effective in making wood and other material fireproof.

After the disastrous fire in Munich on the fourteenth of January, 1823, which completely destroyed the Hof and National Theater, a large number of experiments were made with the result that the wood used in the construction of the roof and other parts of the new theater, was painted with several coats of sodium silicate and chalk.

A coating of this kind lasts for many years and, although it does not render the wood absolutely non-inflammable, it has at least this value that the incipient fire, which, as a rule, begins in quite a small way, meets with resistance at the outset, progresses but slowly and is easily extinguished.

At a somewhat later date, it was discovered that wood saturated with other salts such as, for example, copper sulphate or ammonium phosphate, acquires the property of resisting flame, but of all the salts, zinc chloride seems to be the most efficient for this purpose.

In the first place, zinc chloride has great affinity for, and, therefore, attaches itself readily to, woody fiber, and fibers of all kinds and material saturated with a solution of this salt and then dried are practically non-inflammable. This salt has also this valuable property that it is a powerful antiseptic and therefore very suitable for fireproofing the wood used in the construction of hospitals and other public institutions of a similar nature.

But I do not propose to address you this afternoon at any length on the subject of the fireproofing of wood and other building materials, a subject on which I have made comparatively few experiments and of which I, therefore, have little practical knowledge.

What I wish to discuss, and I hope that the subject will prove in-

teresting to you all, is the problem of the permanent fireproofing of wearing materials and especially of cotton and cotton goods and by permanent fireproofing I mean protection which is not removed when the materials are subjected to the ordinary domestic wash.

Many disastrous accidents are on record which have been brought about by clothing catching fire: sometimes it is the case of a child whose garments have come in contact with a spark or lighted match and sometimes disasters of much greater magnitude have resulted from the ignition of costumes made of tow or other inflammable material on the occasion of charity entertainments or fancy dress balls.

It has long been recognized that impregnation with certain salts very much reduces and indeed may entirely destroy the liability of cotton goods to inflame and, of these fireproofing agents, I may perhaps be allowed to refer to a few only of the better known and more efficient. If a garment, after washing in the ordinary way, is rinsed in a solution containing alum or is starched with a starch containing a proportion of alum, the material, after drying, shows a marked reluctance to ignite, but this treatment has many draw-backs. In the first place it makes the material very dusty, and secondly, the fireproofing is only of a temporary nature since it is at once removed by contact with water and the process must therefore be repeated every time the goods are washed. I can easily demonstrate this and, in these and all my other experiments, I purposely take only very narrow strips in order that any smoke produced may not cause inconvenience in this hall. Another solution which has been strongly recommended for the same purpose is made up with 3 parts of ammonium phosphate, 2 parts of ammonium chloride and 1 part of ammonium sulphate in about 40 parts of water. If the material after washing, is impregnated with this solution and dried, or if it is starched with starch made with the solution instead of with water, the dry material only ignites with difficulty, and, as it does not dust and is not prejudicially affected in any other way, this process has been used with advantage not only in connection with wearing material but also for the fireproofing of lace curtains and other inflammable decorations. But in this case also, the fireproofing agents employed are all soluble in water and one washing is sufficient to remove them entirely, leaving the goods at least as inflammable as before. The process must therefore be repeated every time the goods are washed and this means expense which, in the long run, becomes considerable.

But a much more serious drawback to processes of this kind is the trouble they entail since, in order to fireproof the garment the washerwoman must have alongside the ordinary wash tub, a second tub containing the fireproofing solution and this complication, added to the expense of the salts, has been shown to be so serious that processes of this kind are quite impracticable, especially in the homes of the poor.

Again, unless the materials or garments after washing, have been dried before immersion in the fireproofing solution, this solution can not be kept uniform since, each garment being wet when put in leaves the solution weaker than before and therefore of less protective value. To dry each garment between the washing and the fireproofing entails so much trouble and labor and expense that it would obviously prevent any general adoption of the practise. Although the substances I have mentioned and the salts of ammonium in particular, possess in a high degree the property of rendering material fireproof, there is one substance which confers the property of resisting fire to cotton goods in such a remarkable degree that it has long attracted attention and must be specially mentioned, and that is sodium tungstate.

A piece of muslin soaked in a weak solution of sodium tungstate and then dried is practically non-inflammable but unfortunately this salt is again so excessively soluble in water that a mere rinsing in clean water is sufficient to remove it completely and the fireproofing is lost. And this applies not only to sodium tungstate but also to all the other salts which have, from time to time, been recommended for fireproofing purposes; the result is not permanent because the proofing is at once removed when the goods are washed in the ordinary way.

The problem on which I was engaged for several years and which has now been successfully solved, in a very simple manner, was that of attempting to discover some process which not only made the goods non-inflammable but also *permanently* non-inflammable, and the researches on this subject were originally started in connection with flannelette, a material very largely and widely used for clothing, especially by the poorer classes, and one of the most, if not the most, inflammable of all cotton goods.

Flannelette may be briefly described as a kind of calico the surface of one or both sides of which has been "carded" or "raised" into a nap, the result being that the surface of the calico becomes covered with a fluff of minute fibers somewhat resembling a thin layer of cotton wool. This effect is produced by subjecting the surface of the calico to the action of a series of revolving rollers covered with a vast number of small pieces of sharp steel wire, which tear up the surface, and the material is passed over these rollers over and over again until the required amount of nap has been raised. The result of this superficial covering of nap is—as everybody who has handled flannelette will know—a warm, pleasant and cosy feel and this is no doubt due to a covering of air being imprisoned by the minute fibers thus producing a layer which acts as a non-conductor much in the same way as in the case of flannel.

In the first two samples in the little book which you each received as you entered the hall are calico and flannelette and you will notice at

once the great difference in the feel between the comparatively hard flat surface of the calico and the raised surface of the flannelette.

Flannelette is indeed little, if at all, inferior to flannel as a non-conducting material and as it is very cheap and does not shrink in the wash, it has become very popular and is manufactured in enormous quantities and almost universally used for the clothing of children, especially in the homes of the poorer classes.

But it was not long before its increasing use showed unmistakably that it has one terrible drawback—the nap, which is its peculiar feature, makes it highly inflammable and much more so than the calico from which it was manufactured.

Flannelette is in fact, as I have already said, very much like calico on the surface of which a thin layer of cotton wool has been spread and this layer is, of course, highly inflammable.

I can easily demonstrate the difference in the inflammability of calico and flannelette by applying a light to strips of each, when it will be seen that while calico burns in the ordinary way, in the case of flannelette, the flame flashes over the whole surface of the fluffy cotton layer and travels with extraordinary rapidity.

It is, of course, this property which makes flannelette one of the most dangerous of materials for clothing purposes. The alarming frequency of deaths by burning due to the wearing of flannelette became common knowledge, the coroners all over Great Britain repeatedly called attention to the matter and by degrees the agitation against its use for clothing became so persistent that the Coroners' Committee of the Home Office was directed to inquire into the matter.

The committee recognized that whilst, to quote the words of their report, "We think the common opinion attributing to it (flannelette) a large share of the blame (of burning accidents) is not far wrong" that it was impossible to prohibit its use without causing great hardship, especially to the poor. Several years before this inquiry was held, one of the largest firms of flannelette manufacturers in Manchester, Messrs. Whipp Bros. and Tod, becoming alarmed at the frequent occurrence of fatal burning accidents and fearing lest these might lead to the prohibition of the sale of the material, came to me and asked whether I would undertake a series of experiments with the object of endeavoring to find a remedy for this state of things, and, after looking carefully into the matter, I consented to do what I could. That the problem was a difficult one from many points of view will be readily understood if I briefly state the conditions which had to be kept constantly in mind while the experiments were being carried on. A process to be successful must in the first place not damage the feel or durability of the cloth or cause it to go damp as so many chemicals do, and it must not make it dusty. It must not affect the colors or

the design woven into the cloth or dyed or printed upon it; nothing (such as arsenic antimony, or lead) of a poisonous nature or in any way deleterious to the skin, may be used and the fireproofing must be permanent, that is to say, it must not be removed, even in the case of a garment which may possibly be washed fifty times or more. Furthermore, in order that it may have a wide application, the process must be cheap. What was really to be aimed at was to treat the flannelette in such a way that it acquired practically the properties of wool, which, for all ordinary purposes, may be taken as the standard of a safe material. Apart from the other conditions which I have laid down, when one considers the vigor with which the ordinary washerwoman scrubs garments with soap, not infrequently with the assistance of the scrubbing brush, and takes into account the wonderful mechanical appliances now so largely used for washing clothes with the least expenditure of time, it will not be thought surprising that the discovery of a process of fireproofing sufficiently permanent to resist all these conditions seemed to me at first to be almost an impossibility.

In describing the course of the research, I may perhaps be allowed to give a brief sketch of the development of the subject and to outline the reasoning which led to the institution of the various experiments. Some idea of the difficulty of the subject will be gathered when I say that Mr. Samuel Bradbury, who so ably assisted me in the work and has kept a record of each experiment, tells me that upwards of 10,000 separate burning tests were made before the solution of the problem was reached. Besides these, a great number of further experiments have since been made to see whether an even cheaper process than that which has now been in commercial use for nearly ten years could be discovered.

I suppose that every one would agree that, at the outset of the experiments, the condition which seemed most difficult of realization was that of finding a substance which not only fireproofs, but which during the process becomes so permanently fixed that it will prove to be absolutely resistant to washing with soap and water or mechanical rubbing. Obviously the substance which is to fulfil these conditions must, in the first place, be insoluble in water and secondly in order that it is not liable to be removed by mechanical rubbing and does not render the cloth dusty, it must be fixed in the fiber and not be merely on the surface. I have already explained that when calico is dipped in a dilute solution of sodium tungstate, and then dried the material possesses in a remarkable degree the property of resisting flame and then again alum has often been recommended for the same purpose. Now when solutions of sodium tungstate and alum are mixed, an insoluble aluminum tungstate is produced and it is clear that, if this insoluble salt could be fixed in the fiber, the material would certainly

be fireproof. It furthermore seemed reasonable to suppose that, as the salt is insoluble in water, it would remain in the fiber even after several washings and therefore that permanent fireproofing might be achieved in this manner.

A piece of flannelette was therefore soaked in sodium tungstate and, after passing through rollers, to remove the excess of the solution, left for a considerable time in a solution of alum. It was then squeezed, dried and was passed through the same process again with the result that the material became almost as fire-resistant as asbestos. When, however, the piece was thoroughly washed with soap and water, it was most disappointing to find that the greater part of the fireproofing was removed during the first washing and after several washings the material was little better than the original flannelette.

While this unexpected result was being investigated, it was noticed that aluminum tungstate is soluble in acetic acid and is reprecipitated when the acetic acid is removed by evaporation or by the action of steam and as the precipitate formed seemed granular in appearance, it was thought that this process, if applied to the flannelette, might yield a better result than the process of double decomposition had done. Accordingly, a solution was made up of sodium tungstate, aluminum sulphate and enough acetic acid to dissolve the precipitate, the flannelette was thoroughly soaked in this solution, dried and then placed in an ordinary steamer and subjected to the action of steam until the odor of acetic acid could no longer be detected.

The material was, of course, non-inflammable and when it was washed it was found that this property was distinctly more resistant to soap and water than was the case in the first experiment, but after several vigorous washings almost every trace of the fireproofing had disappeared. These negative results seemed therefore to indicate that aluminum tungstate was not suitable for the purpose of permanent fireproofing. On the other hand, the failure of this salt was possibly due to some peculiarities in its specific properties and was not considered valid evidence that other insoluble tungstates might not combine more completely with the fiber and thus resist removal by washing.

A careful examination of the tungstates was therefore made and such insoluble salts only selected for experiment which, like aluminum tungstate, are colorless, since it is obvious that a fireproofing agent to be of any use must be capable of application to white cloth without staining it. Several hundred pieces of flannelette were treated under the most varied conditions with all sorts of combinations which it was known would precipitate insoluble tungstates in the fiber, but in no case was a satisfactory result achieved.

However, a fact was noticed which afterwards proved to be of value, and it was this, that, of all the salts, the tungstates of zinc and tin

seemed to offer the most resistance to washing with soap and water. Thus, when the material had been thoroughly saturated with a solution made up of sodium tungstate, zinc sulphate and enough acetic acid to prevent the precipitation of the zinc tungstate, and the goods after drying were thoroughly steamed, the fireproofing was certainly fixed to some extent, since it required several washings before the material burnt at all freely. But no amount of variation of the conditions produced a really good result and this combination had therefore to be abandoned. Since the tungstate proved to be unsuitable to the exacting conditions of the problem, a general examination of almost every variety of salt, including ferrocyanides, aluminates, arseniates, antimoniates, zincates and plumbates was made. Many of these could not be employed in connection with wearing apparel in any case because of their poisonous nature, but it was thought that this general examination, which lasted several months, might yield some indication of the type of salt likely to prove resistant to soap and water, if, indeed, such type of salt existed at all. And as a matter of fact these experiments did prove to be most valuable, because when the results were all tabulated, the generalization gradually became apparent that certain soluble salts such as aluminates, antimoniates, zincates and plumbates, in which the oxide of the metal functions as an acid, yielded precipitates, especially with zinc and tin salts which exhibited much greater resistance to washing than the commoner insoluble salts, such as barium sulphate or magnesium phosphate. This generalization ultimately led to a very careful examination of the salts of tin, because, as is well known, the oxides of tin dissolve in alkalis to form stannites and stannates and tin therefore belongs to the class of salts just mentioned and it very soon became evident that these salts do actually possess the power of combining with the fiber to a greater extent than any of the salts which had previously been experimented with.

In one experiment it was noted that a piece of flannelette, which had first been saturated with a solution of sodium stannate and dried, and afterwards similarly treated with a solution of zinc chloride, was quite non-inflammable. After the sample had been subjected to a vigorous washing with soap and water a considerable amount of the fireproofing still remained, because, when a light was applied to the cloth, it only ignited with difficulty, burned very slowly, and either went out of itself or was easily extinguished on shaking the material.

This development was so promising that the experiment was repeated in a great variety of ways, but, although several results were obtained which were much better than anything which had been seen before, it was disappointing to find that in all the cases the greater part of the fireproofing was lost after repeated washings.

In a later series of experiments the first solution was again sodium

stannate and the second consisted of sodium tungstate, zinc acetate and sufficient acetic acid to prevent precipitation of the zinc tungstate formed. The result in this case was so good, the material being practically as safe as wool, even after repeated washings, that the first commercial permanently fireproofed flannelette which was placed on the market was made on these lines.

It was soon found, however, that the material thus treated had two serious drawbacks: it had a tendency to go damp, and an unpleasant smell of acetic acid remained, even though the material had been steamed and washed, after the fireproofing process, before being sent out. And apart from these two faults, the fireproofing was still not sufficiently permanent and the cost of the process was too great for it to be considered a satisfactory one.

A further series of careful comparative tests seemed to indicate that the undoubted advance which had been made was mainly due to the use of the stannate, and it was therefore decided to carry out a series of experiments using salts of tin exclusively.

The fabric, after being treated with sodium stannate as before, was, in the earlier of these experiments, passed through a fixing bath containing stannous chloride. A very permanent fireproofing was again obtained, but the stannous chloride being a reducing agent, tended to destroy or affect the colors of the material, and the process would, therefore, be generally applicable only to white cloth.

In order to get over this difficulty stannic chloride was employed, instead of the stannous salt, as the fixing agent, and to avoid any tendering of the material care was taken that the stannic chloride solution should be of such a strength that a little stannate was left unchanged in the material.

An excellent fireproofing was again obtained, for not only did the material show very little tendency to inflame, after it had been washed several times with soap and water, but it had also in such other respects as appearance and feel almost ideal properties, the only objectionable feature being a slight tendency to dust on rubbing and shaking. Now in this particular experiment, in which sodium stannate and stannic chloride had been employed together, the substance which must have been produced in the fiber, and to which the fireproofing must therefore have been due, is stannic oxide, and it seemed clear that this oxide or its hydrate must have some remarkable power of combining with, or attaching itself to, the fiber which enables it to resist removal by washing and rubbing.

But this process still left something to be desired on the score of economy. A certain amount of the tin was undoubtedly wasted, for, in addition to that lost through a portion of the stannate being left unfixed, it was noticed that a considerable amount of the tin oxide

which was formed by the action of the alkali of the stannate on the stannic chloride, was not permanently fixed in the fibers of the material, and was therefore removed during the subsequent washing. Tin is so expensive that, in a process to be commercially successful, this loss must obviously be avoided.

There are many ways in which stannic oxide may be precipitated from sodium stannate and one of these, commonly used in ordinary analytical chemistry, consists in adding certain soluble salts, such as sodium sulphate or ammonium nitrate to the solution of the stannate, when the whole of the tin is precipitated as oxide or hydrate. In order to find out whether some process of this kind would precipitate this oxide in such a condition that it would remain permanently fixed in the fiber, a number of pieces of flannelette were soaked in sodium stannate and, after thoroughly drying, separately passed through various solutions containing sodium or ammonium salts at the ordinary temperature and at temperatures up to the boiling point. Although, as was to be expected, the results were not uniformly good, a certain degree of permanent fireproofing was always achieved and consequently the matter was systematically followed up with the result that a process was gradually evolved which yielded material possessing quite remarkable properties. The process is briefly this:

The flannelette (or other material) is run through a solution of sodium stannate of approximately 45° Tw. in such a manner that it becomes thoroughly impregnated. It is then squeezed to remove the excess of the solution, passed over heated copper drums in order to thoroughly dry it, after which it is run through a solution of ammonium sulphate of about 15° Tw. and again squeezed and dried.

Apart from the precipitated stannic oxide, the material now contains sodium sulphate and this is removed by passage through water; the material is then dried and subjected to the ordinary processes of finishing. A long series of trials, carried out under the most stringent conditions, have conclusively proved that material, subjected to this process is permanently fireproofed. No amount of washing with hot soap and water will remove the fireproofing agent, or in other words, the property of resisting flame lasts so long as the material itself lasts. I will demonstrate this by exhibiting four different specimens: (*i*) material as it leaves the process and before washing, (*ii*) material which has been washed ten times by hand, (*iii*) material washed 20 times in a machine in a laundry and (*iv*) a portion of a garment which has been in actual use for 2 years, washed every week and is, as you see, in rags. This extraordinary property of resisting soap and water seems to me to indicate that the oxide of tin is not present merely as an insoluble precipitate in the cloth but must have entered into some actual combination with the fiber, yielding a compound which is not broken down by

the action of the weak alkali of the soap. But a matter of hardly less importance from the practical point of view is that the material is not only permanently fireproofed by the process I have just described, it also retains and acquires properties which make it as perfect a material in all other respects as could be desired. In the first place the treatment has no effect on the delicate colors which are now so generally employed in connection with the manufacture of flannelette and other cotton goods and very careful experiments have demonstrated the fact that the insoluble tin compound in the fiber has not the slightest deleterious action on the most delicate skin. In addition, the presence of the tin compound in the pores gives the cloth a softer and fuller feel than that of the original flannelette and what perhaps is the most unexpected result is the fact that the material is considerably strengthened by the process.

A series of tests made by the Manchester Chamber of Commerce proved that the tensile strength of flannelette is increased nearly 20 per cent. as the result of the introduction of the tin compound into the fiber.

Further and very exhaustive tests made at the Municipal School of Technology, Manchester, on a machine specially designed for testing the wearing properties of fabrics, showed an even greater gain in durability in the case of the fireproofed flannelette. These separate and independent tests conclusively showed that the increase in strength and durability was approximately equal to the cost of the fireproofing treatment so that garments made from the permanently fireproofed flannelette are, as a matter of fact, no dearer than those made from ordinary flannelette and are at the same time as safe as if made from flannel. Some of these properties and statements may be easily tested by each of you independently with the samples in the little book which you received on entering the hall.

This permanently fireproofed flannelette is now manufactured on the large scale by Messrs. Whipp Bros. and Tod in Manchester under the name of "Non-Flam" and, although its introduction has been slow, it is being increasingly used and will, in all probability, ultimately entirely replace the ordinary inflammable variety. One of the difficulties experienced in connection with its general introduction is the fact, that, owing to the high price of tin, which is now quoted at about £210 or $1,050 per ton, the cost of the process is not inconsiderable but, even with tin at this high price, the extra cost is not more than 1 d. (2 cents) per yard or about 1½ d. or 2 d. (3–4 cents) for a child's garment. I have here on the table, rolls of "Non-Flam" of different qualities so that any one who wishes for a larger sample than is contained in the little book can easily obtain it.

It is hardly necessary for me to say that this process can be applied

to any cotton fabric and is especially valuable in connection with muslin because this material is so often used, especially on the stage, for dresses which, on account of their flimsy nature, are naturally highly inflammable. I have here two strips of the same muslin, one of which has been treated by the "Non-Flam" process without in any way affecting its ordinary properties and was then washed ten times and the difference in inflammability of the two samples is very striking. Whilst the first sample is highly dangerous, it is difficult to imagine that harm could come to any one who happened to be dressed in the treated material even if, by accident, a lighted match came in contact with the dress. Another direction in which the process may be used with great advantage is in connection with lace curtains. Many disastrous fires have occurred by reason of the ignition of lace curtains and there can be no doubt that the greater majority of these would have been avoided if the curtains had been treated by the "Non-Flam" process. As an example of this, I have here a strip of lace curtain which has been subjected to the process and then washed a number of times and it will be seen that if such material did accidentally come in contact with a lighted match, the danger of fire is reduced to a minimum because even supposing the material did catch fire, the flame is put out at once by the least shake.

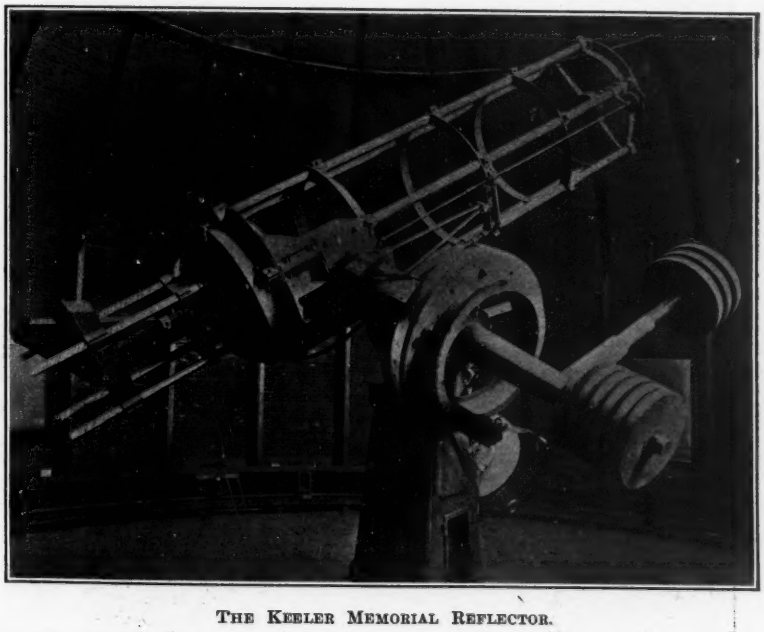
It seems to me that it is obvious that, if this process or some other process capable of giving the same protection from fire, was adopted in the case of all inflammable cotton goods and especially in the case of material used for garments, many disastrous fires and the appalling loss of life especially among young children, might be avoided and it is for this reason that I have ventured to bring the subject of the permanent fireproofing of cotton goods to your notice this afternoon.

THE PROGRESS OF SCIENCE

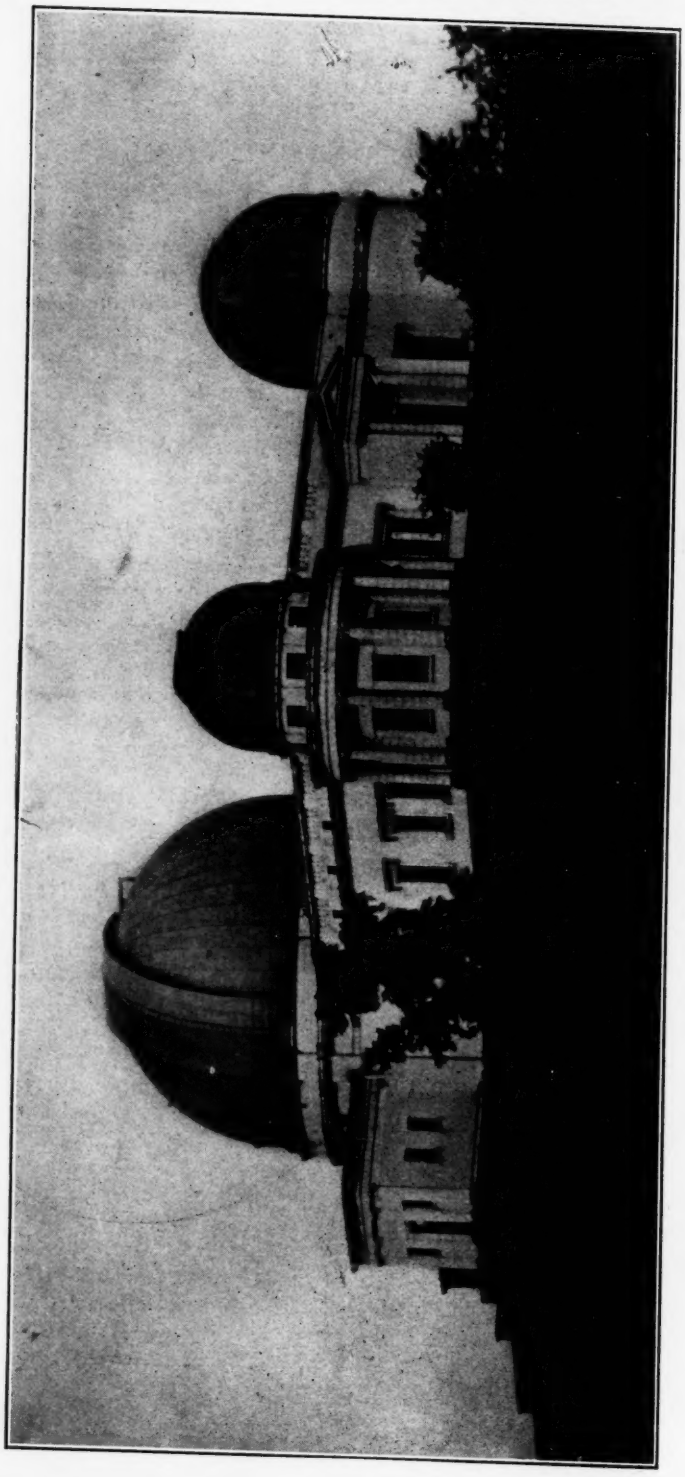
DEDICATION OF THE NEW ALLEGHENY OBSERVATORY

THE new Allegheny Observatory in Riverview Park, Pittsburgh, was dedicated on the afternoon of August 28, in the presence of the members of the Astronomical and Astrophysical Society of America and of many of the Pittsburgh friends of the institution. The new building and its contents have cost about $300,000, the equipment being in quite the first rank. The new site is higher than the old and is farther removed from the city. As the observatory now stands in a large park, it will probably be free from serious encroachments in the future.

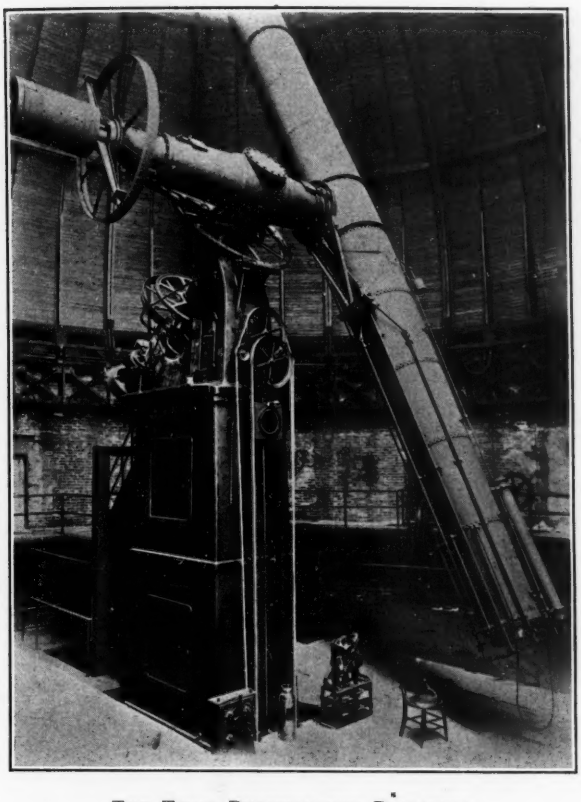
The Allegheny Observatory dates back to 1859, in which year a number of citizens of Pittsburgh and Allegheny organized the "Allegheny Telescope Association" and purchased a 13-inch refracting telescope. Although this telescope was then the third largest in the world, the sole purpose of its owners was "star-gazing," and no attempt was made to use the telescope otherwise until 1867. In that year, chiefly through the efforts of William Thaw, the observatory became the astronomical department of the Western University of Pennsylvania, now the University of Pittsburgh. In the same year the trustees secured the services of Samuel Pierpont Langley as director, who at once set on foot the series of solar investigations that soon gave the observatory and its director an international reputation. In the course of this work Langley invented the bolometer and succeeded in mapping the solar spectrum far into the infra-red. It was at Allegheny, too, that he began his researches on



THE KEELER MEMORIAL REFLECTOR.



THE NEW ALLEGHENY OBSERVATORY.



THE THAW PHOTOGRAPHIC REFRACTOR.

mechanical flight, now recognized as having formed the basis for present-day success in this field.

After Langley had been called to the secretaryship of the Smithsonian Institution at Washington, he was succeeded at Allegheny by his former assistant, James Edward Keeler. His short directorship was marked by the brilliant proof of the meteoric composition of Saturn's rings, one of the best planned and most striking observations of modern astronomy. Keeler persistently urged the necessity of removing the observatory from its original site, upon which the rapidly growing city had by this time seriously encroached. Steps to bring about this removal were under way, but they were temporarily halted in 1898, when Keeler was called to the directorship of the Lick Observatory. But shortly afterwards these efforts were vigorously renewed by Dr. John A. Brashear, who has been chairman of the observatory committee since 1894. The new observatory as it stands to-day is in large measure a tribute to the respect and affection in which Dr. Brashear is held by the people of Pittsburgh.

The plans for the new observatory and its equipment are due to Keeler's immediate successor, Professor F. L. O. Wadsworth, and to the present director, Dr. Frank Schlesinger. The principal instruments are the old 13-inch refracting telescope, a 30-inch reflecting telescope (a memorial to Keeler), and a 30-inch refracting telescope (a memorial to William Thaw and his son, William Thaw, Jr.). The last of these telescopes is not quite complete, as the objective remains to be supplied.

INTERNATIONAL SCIENTIFIC CONGRESSES MEETING IN AMERICA

THE progress of international cooperation in scientific work is exhibited by the large and growing number of congresses holding migratory meetings in different countries, and the greater share taken by America in the advancement of science is born witness to by the fact that these congresses meet with increasing frequency in the United States. The Eighth International Congress of Applied Chemistry has just closed its meeting in Washington and New York, and the Fifteenth International Congress of Hygiene and Demography will be meeting in Washington when this issue of the MONTHLY appears. These are among the most important of such gatherings. Chemistry is the science which, owing to its industrial applications, attracts the largest number of workers, and hygiene and demography occupy an equally important place in our modern civilization.

There were enrolled about 4,500 members for the Congress of Applied Chemistry, of whom 2,173, coming from thirty different countries, were in attendance. They presented 724 papers before the twenty-four sections and the joint sessions of these sections. 570 of the papers were printed in advance in 24 volumes and were distributed to members at the time of the meeting. After preliminary meeting and entertainments in New York City, the congress went to Washington by special train, where the members were received by the president of the United States, who acted as patron of the congress. After the return to New York, the sectional meetings were organized and there were many public lectures, receptions, dinners and excursions. The public lectures included the following: M. Gabriel Bertrand, on "Chemical biology"; Dr. Samuel Eyde, on "The oxidation of atmospheric nitrogen, and the resulting industries in Norway"; Dr. Carl Duisberg, on "The synthetic production of rubber"; Dr. Giacomo Ciamician, on "The photo-chemistry of the future"; Professor William Henry Perkin, on "The permanent fireproofing of cotton goods," which is printed in this issue of the MONTHLY. The entertainments included receptions at the American Museum of Natural History, the Metropolitan Museum and the Chemists' Club; afternoon teas at Columbia University and the College of the City of New York; an excursion up the Hudson, and a grand banquet at the Waldorf-Astoria. At the conclusion of the meeting excursions were arranged to Chicago and to the Pacific coast. Dr. Edward W. Morley was honorary president of the congress and Dr. Wm. H. Nichols was the active president, to whom with the other officers the successful organization and conduct of the congress was in large measure due. The ninth congress will be held three years hence at St. Petersburg under the presidency of Professor Paul T. Walden.

The Fifteenth International Congress of Hygiene and Demography, under the presidency of Dr. Henry P. Walcott, of Massachusetts, will undoubtedly be equally notable. An important and interesting scientific program and exhibit have been arranged. Some 300 German physicians have already arrived in New York to attend the meetings. Mention should also be made of the International Otological Congress at Boston under the presidency of Dr. Clarence J. Blake, which though smaller and attracting less attention, has brought to this country a number of distinguished foreign otologists. Two further gatherings of foreign scientific men in this country deserve mention—the transcontinental excursion of the American Geographical Society and the dedication of the Rice Institute. The former is quite unique in character. The American Geographical Society, to celebrate the

THE LATE PROFESSOR L. J. TROOST, OF THE UNIVERSITY OF PARIS, THE DISTINGUISHED CHEMIST, IN THE UNIFORM OF THE PARIS ACADEMY OF SCIENCES.

sixtieth anniversary of its foundation and the completion of its new building, planned a transcontinental excursion under the conduct of Professor William M. Davis, of Harvard University, to which the leading geographical societies of Europe were invited to appoint delegates as guests. There were about forty acceptances, including many of the leading geographers of the world, who with their American colleagues are at present engaged in an excursion across the continent lasting about two months. An international character has been given to the inauguration of the Rice Institute at Houston, Texas, by inviting twelve distinguished foreign scientific men and scholars to prepare each three lectures for the proceedings of the opening festival, to be published in a series of volumes which will be issued in commemoration of the

occasion. Among the lecturers who will be present are Professor Emil Borel, of Paris; Professor Hugo de Vries, of Amsterdam; Professor Wilhelm Ostwald, lately of Leipzig; Sir William Ramsay, of London, and Professor Vito Volterra, of Rome.

While a larger group of foreign scientific men are in this country than ever before, a considerable number of American scientific men have attended three international congresses held in England—the First International Congress of Eugenics, to which reference has already been made in this journal; the International Congress of Entomology at Oxford, and the International Congress of Mathematicians at Cambridge. The meeting of the British Association for the Advancement of Science at Dundee has also assumed international proportions, in view of the large number of foreign men of science in attendance.

THE ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION

THE presidential address before the British Association for the Advancement of Science given by Professor E. A. Schäfer, of the University of Edinburgh, at Dundee, on September 4 has attracted much attention in view of the popular interest in questions concerned with the nature, origin and maintenance of life. While the address does not contain new facts or theories, it is a clear and excellent statement of the chemico-mechanical explanation of life. The entire address was published in the issue of *Science* for September 6. We may quote several paragraphs, which are characteristic of the line of argument:

"It is not so long ago that the chemistry of organic matter was thought to be entirely different from that of inorganic substances. But the line between inorganic and organic chemistry, which up to the middle of the last century appeared sharp, subsequently became misty and has now disappeared. Similarly the chemistry of living organisms, which is now a recognized branch of organic chemistry, but used to be considered as so much outside the domain of the chemist that it could only be dealt with by those whose special business it was to study 'vital' processes, is passing every day more out of the hands of the biologist and into those of the pure chemist.

"Somewhat more than half a century ago Thomas Graham published his epoch-making observations relating to the properties of matter in the colloidal state: observations which are proving all-important in assisting our comprehension of the properties of living substance. For it is becoming every day more apparent that the chemistry and physics of the living organism are essentially the chemistry and physics of nitrogenous colloids. Living substance or protoplasm always, in fact, takes the form of a colloidal solution. In this solution the colloids are associated with crystalloids (electrolytes), which are either free in the solution or attached to the molecules of the colloids. Surrounding and enclosing the living substance thus constituted of both colloid and crystalloid material is a film, probably also formed of colloid, but which may have a lipoid substratum associated with it (Overton). This film serves the purpose of an osmotic membrane, permitting of exchanges by diffusion between the colloidal solution constituting the protoplasm and the circumambient medium in which it lives. Other similar films or membranes occur in the interior of protoplasm. These films have in many cases specific characters, both physical and chemical, thus favoring the diffusion of special kinds of material into and out of the protoplasm and from one part of the protoplasm to another. It is the changes produced under these physical conditions associated with those caused by active chemical agents formed within protoplasm and known

as *enzymes*, that effect assimilation and disassimilation. Quite similar changes can be produced outside the body (*in vitro*) by the employment of methods of a purely physical and chemical nature. It is true that we are not yet familiar with all the intermediate stages of transformation of the materials which are taken in by a living body into the materials which are given out from it. But since the initial processes and the final results are the same as they would be on the assumption that the changes are brought about in conformity with the known laws of chemistry and physics, we may fairly conclude that all changes in living substance are brought about by ordinary chemical and physical forces.

"Should it be contended that growth and reproduction are properties possessed only by living bodies and constitute a test by which we may differentiate between life and non-life, between the animate and inanimate creation, it must be replied that no contention can be more fallacious. Inorganic crystals grow and multiply and reproduce their like, given a supply of the requisite pabulum. In most cases for each kind of crystal there is, as with living organisms, a limit of growth which is not exceeded, and further increase of the crystalline matter results not in further increase in size but in multiplication of similar crystals. Leduc has shown that the growth and division of artificial colloids of an inorganic nature, when placed in an appropriate medium, present singular resemblances to the phenomena of the growth and division of living organisms. Even so complex a process as the division of a cell-nucleus by karyokinesis as a preliminary to the multiplication of the cell by division—a phenomenon which would *primâ facie* have seemed and has been commonly regarded as a distinctive manifestation of the life of the cell—can be imitated with solutions of a simple inorganic salt, such as chloride of sodium, containing a suspension of carbon particles; which arrange and rearrange themselves under the influence of the movements of the electrolytes in a manner indistinguishable from that adopted by the particles of chromatin in a dividing nucleus. And in the process of sexual reproduction, the researches of J. Loeb and others upon the ova of the sea-urchin have proved that we can no longer consider such an apparently vital phenomenon as the fertilization of the egg as being the result of living material brought to it by the spermatozoon, since it is possible to start the process of division of the ovum and the resulting formation of cells, and ultimately of all the tissues and organs—in short, to bring about the development of the whole body—if a simple chemical reagent is substituted for the male element in the process of fertilization. Indeed, even a mechanical or electrical stimulus may suffice to start development. *Kurz und gut*, as the Germans say, vitalism as a working hypothesis has not only had its foundations undermined, but most of the superstructure has toppled over, and if any difficulties of explanation still persist, we are justified in assuming that the cause is to be found in our imperfect knowledge of the constitution and working of living material. At the best vitalism explains nothing, and the term 'vital force' is an expression of ignorance which can bring us no further along the path of knowledge. Nor is the problem in any way advanced by substituting for the term 'vitalism' 'neo-vitalism,' and for 'vital force' 'biotic energy.' 'New presbyter is but old priest writ large.'"

SCIENTIFIC ITEMS

WE record with regret the deaths of Dr. W J McGee, known for his contributions to geology, anthropology and the conservation of natural resources; of Dr. T. B. McClintic, of the United States Public Health Service, who died

of Rocky Mountain spotted fever, contracted while investigating the disease in Montana; of Dr. Humphrey Owen Jones, F.R.S., the English chemist, who with his wife was killed while ascending the Aiguille Rouge de Pentéret, in the Alps; of Mr. Robert Holford Macdowall Bosanquet, F.R.S., known for his researches in acoustics and magnetism, and of M. Lucien Lévy, the distinguished French mathematician.

DR. WILHELM WUNDT, professor of philosophy in the University of Leipzig, one of the founders of modern psychology, celebrated his eightieth birthday on August 16, on which occasion a "Wilhelm Wundt Stiftung," amounting to 7,000 Marks, was presented to the university by his students and friends.—In connection with the visit to Dundee of the British Association for the Advancement of Science, the senate of the University of St. Andrews has conferred the degree of LL.D., on sixteen foreign men of science who attended the meetings of the association. As a recognition of the president of the association, Professor E. A. Schäfer, of Edinburgh University, they are largely physiologists. The United States is represented by Dr. S. J. Meltzer, of the Rockefeller Institute of Medical Research.

THE movement for the enlargement of the health activities of the United States government has resulted in the passage of a law which enlarges the functions of the Public Health and Marine-Hospital Service and changes the name to the "United States Public Health Service." Under this law the new Public Health Service is given very wide authority to investigate the "diseases of man and conditions influencing the propagation and spread thereof, including sanitation."